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MALIGNANT TUMORS OF THE THYROID

By LOUIS B. WILSON, M.D.

OF ROCHESTER, MINNESOTA

Introduction.—Correct early diagnoses of malignant tumors of the thyroid are made probably less frequently than of malignant tumors involving any other organ of the body. This results in treatment being deferred in most cases until it is useless. The mortality, therefore, is very high, although the incidence of the disease is less than of malignant disease of many other organs. This low incidence, however, is probably more apparent than real and is at least partially due to the failure in many cases to recognize the presence of the disease in either the living or the dead, since the symptoms are frequently not referable to the thyroid itself, and since post-mortems are altogether too rare.

The object in this paper is to call the attention of internists, surgeons, and pathologists to the unappreciated relative frequency of the malignant tumors of the thyroid, to summarize the principal observations in a pathologic study of the cases which have been observed in the Mayo Clinic from January 1, 1901 to January 1, 1921, and to present for convenience of reference a bibliography covering the subject during the last fourteen years.

Review of Literature.—In 1906 Müller and Speese presented a fairly inclusive bibliography and an excellent summary of the literature up to that date. They summarized Ehrhardt's report of 150 collected cases of carcinoma and ninety-nine cases of sarcoma. To these they added twenty-three cases of carcinoma collected from the literature subsequent to Ehrhardt's report and eight cases of their own. They also brought the collected cases of sarcoma up to 117, including one case of their own. The references given herewith include only those omitted by Müller and Speese and those of articles appearing since the publication of their article. During this period aside from detailed data of individual cases the most important articles are those by Langhans and by Kocher. In American literature four significant reviews with reports of cases have appeared. These are by Crotti, Binney, Porter, and Bouman. The most important contribution which has appeared at any time on the pathology is that by Langhans. Bouman's paper gives an excellent summary of Langhans' article.

ETIOLOGY

General Incidence.—Our knowledge of the general incidence of malignant tumors of the thyroid is very meagre for lack of accurate data. That there is

TABLE I
INCIDENCE OF MALIGNANT TUMORS OF THE THYROID SHOWN BY NECROPSY RECORDS

Source of information	Locality	Necropsies	Tumors	Proportion
Müller and Speese.....	Berne.....	7,641	82	1:93
Müller and Speese.....	Vienna.....	18,147	50	1:362
Müller and Speese.....	Prague.....	7,700	17	1:452
Totals for Europe.....	.....	33,488	149	1:224
Personal communications from pathologists in thirteen hospitals January 1, 1917.....	Atlantic slope, Baltimore, and cities north thereof	26,375	14	1:1883
Personal communications from pathologists in three hospitals January 1, 1917.....	Pacific slope, San Francisco.....	2,966	14	1:211
Personal communications from pathologists in ten hospitals January 1, 1917.....	Upper Mississippi Valley, St. Louis, and cities north thereof, exclusive of Rochester, Minnesota	7,638	3	1:2546
Necropsy records, Mayo Clinic, January 1, 1905, to December 16, 1920.....	Rochester, Minnesota (patients mostly from Minne- sota and neighboring states).....	3,868	13	1:297
Totals for the United States.....	Upper Mississippi Valley, including Mayo Clinic..	(11,506)	(16)	(1:719)
Grand Totals.....	.....	40,847	44	1:928
	.....	74,335	193	1:385

MALIGNANT TUMORS OF THE THYROID

apparently very great variation in incidence is shown by necropsy records in Table 1.

It will be seen that in Berne, one case of malignant tumor of the thyroid was found in every ninety-three post-mortems. This high incidence may be accounted for not only by the high rate of goiter in Switzerland, but also by the presence of Kocher's clinic which attracted goitrous patients from other regions. In Prague the incidence was only one in 452 post-mortems.

In the United States, from information received on request from hospitals where competent pathologists have been in charge of the necropsy service for many years, the highest incidence is in San Francisco, where it is one in 211, and the lowest in the upper Mississippi valley, where it is one in 2,546. This ratio may be influenced by the omission of the cases seen in the Mayo Clinic. In the Mayo Clinic the incidence is one in 297. When this is combined with that of the remainder of the upper Mississippi valley the ratio is one in 719. Although the Mayo Clinic attracts a large number of goitrous patients, particularly from the upper Mississippi valley, the ratio (9:5) of "simple" goiters (the group in which most malignant tumors are said to occur) to exophthalmic goiters is much less than in Kocher's clinic. It must be remembered, however, that these data are very incomplete.

TABLE 2

MALIGNANT TUMORS OF THE THYROID CONCERNING WHICH INFORMATION IS AVAILABLE

Source of information	Epithelial tumors	Sarcomas	Undetermined	Total
Müller and Speese, summary to 1906.....	181	118	...	299
Literature 1906 to 1920*.....	524	39	109	672
Reported in personal communications to author by sixty-seven American surgeons January 1, 1917..	98	19	52	169
Mayo Clinic cases, January 1, 1905, to January 1, 1921.				
Positive.....	115	19	83 (Not operated on)	290
Doubtful.....	73			
Total.....	991	195	244	1,430

* Reports included in bibliography.

The total number of cases of malignant tumors of the thyroid which have been detailed in the literature to date is probably not more than 1,000 (Table 2). Eliminating duplicates the writer was able to collect only 971. Only thirty-four of these have been reported by American authors. It is interesting to compare this small number with the 169 cases reported in personal communications to the writer by sixty-seven American surgeons (not including those in the Mayo Clinic) up to January 1, 1917. At that time none of these 169 cases had been reported in the literature. It will be seen that almost five times as many cases have been met with in the experience of a very small number of American surgeons as had appeared in the entire literature from all American sources. The explanation of this failure to report

cases is found in the reluctance which everyone has in reporting cases of which his primary diagnosis was usually incorrect and his treatment futile.

Much of the common impression that malignant tumors of the thyroid are relatively rare is believed to be due in part at least to the high percentage of error of diagnosis. In the Mayo Clinic, of the ninety-seven patients operated on who have died of the disease or who when last heard from were known to have undoubted recurrences, usually metastatic, there were fifty whose clinical histories before the first operation contained no suggestion of malignancy. The glands removed at operation from all of the ninety-seven were examined pathologically, yet at the first operation twenty-three of these were passed by the pathologist without suspicion of malignancy. It is believed that in the last three or four years the percentage of accuracy of diagnosis, both clinical and pathologic, has been very greatly increased in the Clinic, but it is too early to obtain complete mortality statistics in the cases. It is suggested that surgeons should follow up their patients operated on for adenoma of the thyroid, especially after the lapse of three or more years, in order to determine the incidence of death from or recurrence of tumors the malignancy of which was not suspected at the time of operation.

Our knowledge of the relative incidence of malignant tumors of the thyroid compared with our knowledge of malignant tumors of other organs is based on very incomplete information. The impossibility of drawing accurate conclusions from the data at hand is well shown by the marked contrast in the data given by Williams from his analysis of 15,481 primary tumors met with consecutively in the experience in the metropolitan hospitals (London) when compared with the number of tumors found at operation in the Mayo Clinic during sixteen years (Table 3).

TABLE 3
RELATIVE INCIDENCE OF MALIGNANT TUMORS OF THE THYROID AND OF MALIGNANT TUMORS OF OTHER ORGANS OBSERVED AT OPERATION

Organ	Williams (metropolitan hospitals, London)	Mayo Clinic (January 1, 1905, to December 1, 1920)
Uterus.....	2,649	1,006
Breast.....	2,442	1,968
Stomach.....	352	2,073
Lip.....	352	536
Prostate.....	9	140
Thyroid.....	23	207 (plus 83 not operated on)

Geographic Incidence.—Inaccuracy of diagnosis is so large a factor as to render vital statistics even in registration areas practically useless for determining the geographic incidence of malignant tumors of the thyroid. Morbidity statistics drawn from even extensive surgical experience like that of Kocher or of the Mayo Clinic embrace a territory too wide and too incompletely covered to be of much value. Thus, in the experience in the Mayo

MALIGNANT TUMORS OF THE THYROID

Clinic, although each year since 1910 a much larger number of patients have registered from Minnesota than from Iowa, and a larger number of patients with simple goiters have come from Minnesota than from Iowa, there has been a much larger number of patients with malignant tumors of the thyroid from Iowa than from Minnesota. These facts were thought to have some significance when first brought out by the compilation of data. A control study, however, was made of the malignant tumors of the breast, and it was found that each year of the same period, except 1910, the total number of patients with malignant tumors of this organ coming from Iowa was greater than those coming from Minnesota. It is now believed that these facts have no etiologic significance, but are influenced by other factors, such as the distribution of surgeons, and the local reputation of places of operation.

While Kocher and most other authors assert with some degree of positiveness that malignant tumors of the thyroid have a greater geographic incidence in those areas in which simple goiters abound, the American necropsy records quoted in Table 1 and the diagnostic experience in the Mayo Clinic give no apparent support to this hypothesis, which may nevertheless be correct.

Incidence in Thyroid Cases.—Kocher quotes 235 cases in his own series, on which he had complete data and seventy-six on which he had incomplete data. These were in an operative experience in about 3,500 cases of goiter. He thought he had seen incidentally or in private consultation approximately 100 more cases. In the Mayo Clinic up to January 1, 1921, 10,682 simple goiters and 5,867 exophthalmic goiters had been operated on. Of these 207 were malignant. Besides these 207 there were eighty-three cases in which the diagnosis of malignancy was made but which were inoperable.

None of these patients gave a previous history of true exophthalmic goiter, although the presence of symptoms of true exophthalmic goiter in patients with malignant tumors of the thyroid has been noted by a number of observers.

Age Incidence.—In Müller's and Speese' collection, the age incidence at the time of diagnosis is greatest in the fourth, fifth, and sixth decades, with the preponderance in the sixth. In the Mayo Clinic cases the age incidence is similarly greatest in these three decades, but with the preponderance in the fifth.

Sex Incidence.—Müller and Speese place the sex incidence as sixty per cent. in women and forty per cent. in men. In the Mayo Clinic the percentage is sixty-nine in women and thirty-one in men. The distribution by sex is shown in Table 4.

Premalignant Local Conditions.—Of the 290 patients in the Mayo Clinic 158 had developed goiter before they were thirty and 106 in the next two decades. One hundred fifty-nine patients had had thyroid enlargement for five years or more. Only sixty-one patients had not noticed thyroid enlargement previous to one year before diagnosis of malignancy. It is probable that a malignant neoplasm of the thyroid may exist for a considerable period with-

TABLE 4

MALIGNANT TUMORS OF THE THYROID, DISTRIBUTION BY SEX (MAYO CLINIC)

	Males	Females	Total
Carcinomas, operated on.....	24	38	62
Carcinomas (?) not operated on.....	29	54	83
Malignant adenomas.....	19	83	102
Malignant papillomas.....	9	15	24
Sarcomas.....	8	11	19
Total.....	89	201	290
	31 per cent.)	(69 per cent.)	

out causing pressure or other symptoms which compel the patient to seek medical advice. This renders all statistics concerning premalignant conditions very inaccurate.

COURSE OF THE DISEASE

Onset.—It is frequently difficult to elicit a history of definite onset of symptoms referable to malignancy as distinguished from symptoms referable to the presence of supposedly benign tumors of the thyroid. Usually the first symptom leading to suspicion is an increase in size of the gland at a rate greater than that which has continued for some years. Yet this increased growth rate is rapid in only about one-third of the cases, gradual in one-third, and slow in the remainder. Growth usually progresses steadily and without periods of regression in size such as are usually seen in thyroid enlargements of inflammatory origin.

Of the total number of patients examined in the Mayo Clinic about one-fourth had noticed symptoms of continuous growth for one year or less, and about one-third had noticed symptoms of continuous growth for ten years or more. It may be doubted whether the process in the latter was malignant from the beginning of the continuous period of growth. Of the patients whose conditions were considered inoperable at the time of their first examination in the Clinic, more than one-half had noticed symptoms which might be interpreted as indicative of the presence of malignant tumor for one year or less, while one-fourth of them had noticed similar symptoms which had existed for ten years or more. Thus it will be seen that while a sudden increase in rate of growth of a long standing nodular tumor of the thyroid in a patient more than thirty-five is strongly indicative of beginning malignancy, a slow, continuous growth may be almost equally indicative of the same condition. This distinction is important because in much of the older literature the impression is given that the excessive rate of growth is almost always very rapid.

The surface of a malignant thyroid is more apt to be irregular and nodular than when the enlargement is due to inflammation. The irregular nodules are readily palpable. They are, however, not more irregular or nodular at the beginning than are nonmalignant adenomas.

MALIGNANT TUMORS OF THE THYROID

Accompanying the thyroid enlargement, and due to it, are symptoms of pressure on the larynx, trachea, œsophagus, and neighboring nerve trunks. The voice may change, usually deepening. There may be coughing and excess of mucus from the trachea. Even early there may be difficulty in swallowing. Pain in the region of the thyroid, in the neck generally, and extending behind the ears and outward to the shoulders may be an early symptom. There are likely to be cardiovascular disturbances such as arrhythmias, palpitation, and pain resembling angina pectoris. At this early period, the patient's general health may be good, and he may continue his usual vocation until the disease is well advanced before seeking medical advice.

Development.—As the disease progresses all the symptoms become aggravated. The pain may become more constant and neuralgic in character. As infiltration of the surrounding tissues occurs the patient complains of "drawing" pains in the gland, which is also tender on pressure. The trachea is often infiltrated, although sometimes only displaced. Invasion of the trachea interferes with its blood supply, causing edema and dyspnœa. Intratracheal hemorrhage may develop early. Interference with respiration may become serious; the patient sleeps in a sitting posture. The pressure on the œsophagus may cause dysphagia. Difficulty in swallowing is probably due at first to spasm, but later to direct pressure.

Later the tumor may become large, hard, and immovable. The pressure from it causes the veins of the neck and arms to stand out prominently. The skin over the tumor becomes red and adherent to it. The patient loses weight and strength rapidly. Cachexia is not nearly so common as in cases of tumors of the alimentary canal, for example, being noted in perhaps not more than one-fifth of all fatal cases.

Metastatic deposits are most frequent in the lungs. The skull, brain, and liver are also frequent sites. A few cases have been reported of malignant tumors of thyroid tissue in organs distant from the thyroid in which necropsy revealed no evidence of malignancy in the thyroid itself.

Termination in Nonoperated Cases.—The case may terminate early from edema of the glottis. This is rare, however, and the course of the disease is usually very much prolonged, death finally occurring either from local invasion of neighboring organs or from the effects of extensive metastasis, usually to the lungs, brain, or liver.

Effects of Operation on the Course of the Disease.—Early thorough operation gives a fair percentage of cures. When the tumor is in the intracapsular stage and metastasis has not already begun complete resection of the entire lobe of the thyroid involved may result in permanent cure. Unfortunately, however, in a very large percentage of cases the clinical diagnosis is not made until the malignant growth has perforated the capsule of the gland and neighboring organs are extensively involved, or until metastasis to distant organs is well marked.

Another common source of failure of surgical procedures is the surgeon's inability to recognize at operation the malignant character of the growth.

The pathologist also is frequently at fault in his diagnosis. This is particularly true in Langhans' "wucherende Struma," or malignant adenoma. These tumors are frequently diagnosed even on microscopic examinations "fetal adenoma" and the patient sent home with a favorable prognosis. However, he is likely to return in six months or a year with extensive local recurrence. Even at this time the character of the growth is not always recognized either grossly or histologically, and the patient again may be told that the tumor is only benign. These recurrences in proliferating adenomas may come at intervals of from six months to three years for four to eight years before they finally, either by their very great increase in size locally or more usually by extensive metastasis to the lungs, the brain, or the liver, cause death. The great lesson for the surgeon to learn in all nodular tumors of the thyroid in patients of cancer age in which there is not positive evidence of nonmalignancy is that the operation must be radical to the extent of removing every portion of nodular adenomatous thyroid tissue of the side involved. It may even be necessary to clear out all thyroid tissue on both sides, trusting to thyroid feeding for the patient's future metabolic balance. The pathologist must be on the alert to distinguish, if possible, these proliferating tumors from ordinary slow-growing adenomas and adenomatoses.

Surgical operations in late cases after extensive involvement of neighboring organs or distant metastasis may be only palliative; as such, they are frequently warranted.

A detailed study of the results of operation in the cases in the Mayo Clinic is being made by Dr. W. P. Herbst. A brief summary of the post-operative results, however, may be seen in Table 5.

TABLE 5
PERIOD OF RECURRENCE AFTER OPERATION FOR MALIGNANT TUMORS OF THE THYROID

Cases	Patients heard from	Recur- rences	1 or less	Years, postoperative												
				2	3	4	5	6	7	8	9	10	11	12	13	
Malignant papillomas. 24	24	8	6	...	...	...	1	...	...	...	1	...	...	...
Malignant adenomas and carcinomas..... 164	152	138	44	36	27	9	8	7	3	1	...	2	...	1		
Sarcomas..... 19	18	18	16	2	...	...	...	...	...	...	...	...	...	...
Total..... 207	194	164	66	38	27	9	9	7	3	1	0	1	2	0	1	

The average postoperative life of patients who died of malignant tumors of the thyroid after having been operated on in the Mayo Clinic, or whose conditions were considered inoperable at the time of diagnosis, was approximately six months for patients operated on for sarcoma and for patients with inoperable malignant tumors of unverified type. It was approximately one year and five months for patients with carcinomas, or malignant adenomas, and two years and nine months for patients with malignant papillomas.

MALIGNANT TUMORS OF THE THYROID

PATHOLOGIC CLASSIFICATION AND DIAGNOSIS

General Considerations.—Thyroid enlargements aside from hyperemia and inflammatory deposits vary so much in structure and present so little apparent relationship between their structure and the associated symptoms that diagnosis and classification are always extremely difficult. Perhaps for a clearer understanding we may lay aside for the moment our previously conceived ideas, our theories with regard to origin, and our impressions derived from exceptional or limited observations, and attempt first to blaze out certain broad general conceptions of the group.

Speaking from an experience gained in the pathologic study of about 14,000 human thyroids it seems to me that the following general conceptions may be formulated: Aside from hyperemia and inflammatory deposits, thyroid enlargements, as met with at operation and necropsy, are directly due either to storage of secretion or proliferation of tissue or to both. If due to storage of secretion, they are colloid goiters. If due to diffuse proliferation (hyperplasia) of normal adult tissue which hyperfunctions, they are exophthalmic goiters. If due to circumscribed proliferation of (usually embryonal) parenchymatous tissue, they are adenomas. If these adenomas remain perfectly encapsulated and if they cease to proliferate and gradually degenerate they are "benign," in the sense that they do not invade surrounding structures and do not metastasize. They may, however, cause untoward local symptoms from pressure and they may be associated with a symptom syndrome, the chief characteristic of which is usually a slowly developing hypermetabolism with cardiac disturbances but rarely with exophthalmos, a syndrome which H. S. Plummer designates "toxic non-exophthalmic goiter" or "toxic adenoma."

If adenomas continue to proliferate rather than to degenerate they may penetrate their capsule, invade the other portions of the gland or surrounding structures and metastasize, ultimately causing the death of the patient by destruction of either local or distant organs. These proliferating adenomas (the "wucherende Struma" of Langhans) thus may or may not be malignant and histologically it is almost impossible to differentiate the two. Broadly speaking, the only reliable marks of distinction are the details which indicate the predominance of one or the other of the two processes, namely proliferation and degeneration. Again, broadly speaking, it follows from this, that any sizable adenoma of the thyroid composed of embryonal tissue in a person of cancer age which histologically shows that it is in active proliferation is potentially malignant even though it is still contained entirely within its capsule. This consideration, based on data supplied by a competent pathologist, should guide the surgeon at the time of operation in the extent of his operative procedures.

Neoplasms of the thyroid composed of adult parenchymatous cells, if encapsulated, always suggest having been derived from embryonal tissue during postnatal life though by no means can this always be proved. Langhans considers them late stages of "wucherende Struma." Such encapsulated masses of large adult parenchymatous cells, while frequently arranged in

acini resembling those of the normal thyroid, are more frequently the subject of extensive degeneration. And such degeneration may be sufficiently extensive to produce sloughing or broken-down areas. The epithelial cells adjacent thereto are large, often with hydropic cytoplasm and relatively small nuclei. The parenchyma is not infrequently markedly papilliferous. Such adenomas composed of epithelium, apparently adult in all respects, are associated with clinical conditions parallel with those mentioned as coincident with adenomas of embryonal type. They may cause only local pressure symptoms, they may be associated with the syndrome of toxic adenoma (Plummer) or they may invade surrounding structures and metastasize to distant organs thus placing them in the class of malignant neoplasms. They are undoubtedly the origin of that group of malignant tumors usually designated adenocarcinomas.

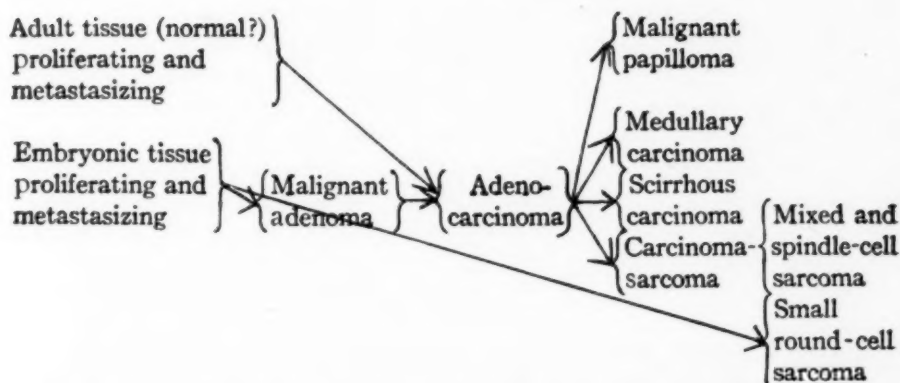
Occasionally there is met with an aberrant diffuse proliferation of parenchyma of the thyroid with little or no evidence of the formation of normal secretion or of the storage of colloid and without evidence of encapsulation except the normal capsule of the entire lobe. It is believed that such tumors may exist without causing other than local symptoms and these but slight. I have seen not more than ten or fifteen of these in my entire experience. On the other hand, solid homogeneous non-functionating aberrant proliferations of the thyroid are almost always neoplasms which invade surrounding structures and metastasize to distant organs. While in one sense these are adenocarcinomas, for the sake of clearness, let us leave out of account their suggestion of nodular encapsulated neoplasms and refer to them simply as carcinomas of the thyroid.

All other tumors of the thyroid associated with symptoms of malignancy are usually described as sarcomas. Beside their connective tissue elements in which any form of sarcoma cell may be the dominant one, although it is most frequently the spindle-cell type, there are also almost invariably present large or small groups of parenchymatous cells which show that they are also proliferating. Whether or not the neoplastic process started with the parenchymal elements which were later destroyed by a secondary proliferation of the connective tissue elements, or whether the process was from the beginning a proliferation of the connective tissue elements with only secondary stimulation of the parenchymatous cells as they were gradually squeezed out, it is impossible to say. There is usually a history of recent rapid development, and the prognosis of the early demise of the patient must be made. We must continue to call these tumors sarcomas whatever may be our hypothesis with regard to their epithelial or mixed origin.

MORPHOLOGIC RELATIONSHIPS

In studying the pathologic diagnosis of malignant tumors of the thyroid, some assistance may be obtained by following in reverse order, the diagram presented herewith:

MALIGNANT TUMORS OF THE THYROID



This diagram is an attempt to express what appear to be the gradations from tumors of one type of tissue to those of other types which have been found in the series of malignant tumors of the thyroid herewith reported. It is possible that other types exist, but they have not come under my observation. Thus, no hard and fast line of differentiation can be drawn between tumors composed of embryonic tissue (fetal adenoma, wucherende Struma, Langhans) which is proliferating and metastasizing and those types of adenomas composed of cells approaching the adult type but arranged in fairly normal acini or in bands. Nor is it possible to draw hard and fast lines between tumors of this latter type of tissue and tumors composed of cells of more or less adult type forming tissue masses, most of which are composed of cells rather densely packed together and showing only here and there enough evidence of their acinar arrangement to indicate their thyroid gland origin, and hence called adenocarcinomas. Adenocarcinomas in turn are subject to at least four types of variation, which in their extreme development are readily recognized, but which grade into ordinary adenocarcinoma of the solid type and even into each other in all degrees of variation. As a rule it is much easier to determine histologically the malignancy of adenocarcinomas, including the four principal variations, papilloma, medullary carcinoma, scirrhus carcinoma, and carcinosarcoma, than it is to determine histologically the malignancy of either adult or embryonic adenomas.

ILLUSTRATIVE CASES

The following illustrations show the principal tumor types in inverse order of the diagram beginning with those which are most easily recognized. The illustrations are presented in the hope that they may assist other observers in making diagnoses. Only enough of the clinical history is presented to serve as a check on the pathologic diagnosis.

MALIGNANT PAPILLOMA

Case I (A53517). A man, aged sixty-five, had had goiter two years before operation. The left lobe, isthmus and lower pole of the right lobe were extirpated. Sixty grams of tissue were removed. Recurrence followed in eight months, and the patient died three years after the operation.

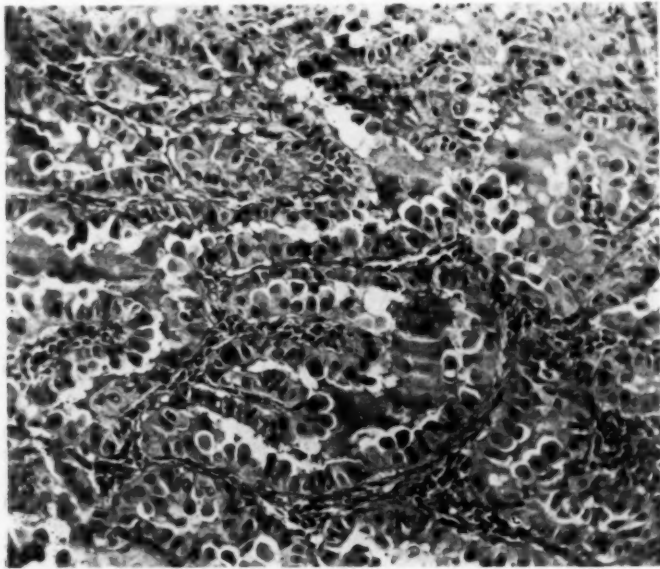


FIG. 1 (Case A53517).—The papillæ bear large functioning cells (see colloid and surrounding clear spaces) with sharply-staining nuclei, and mitotic figures. Malignant papilloma. X100.

MALIGNANT TUMORS OF THE THYROID

MALIGNANT PAPILLOMA

Case II (A85166). A man, aged fifty-one, had had goiter for eighteen months; rapidly growing for five months. At operation a malignant papilloma of the right lobe, involving the trachea and muscles was found. One hundred thirty-two grams of tissue were removed. There was a rapid recurrence of the tumor and the patient died two and one-half months after the operation.

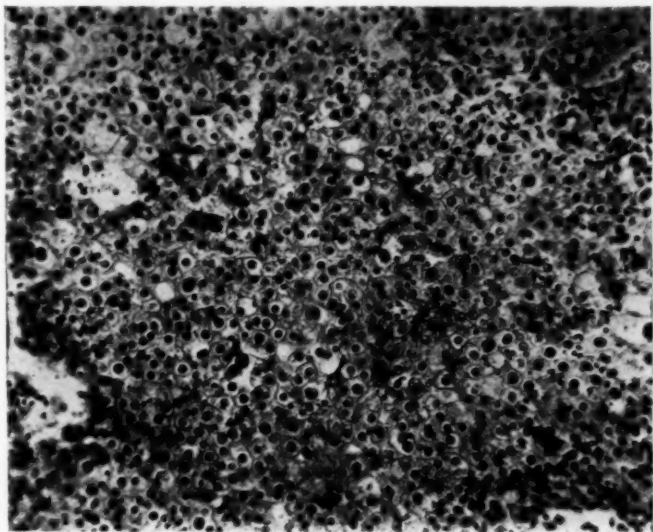


FIG. 2 (Case A85166).—A section through the base of the papillæ which resemble those shown in Figure 1. Large and small epithelial cells, showing evidence of rapid proliferation. Malignant papilloma. X100.

NON-MALIGNANT PAPILLOMA

Case III (39582). A woman, aged thirty-seven, had had goiter for two years. The left lobe and isthmus were extirpated. The growth was a papilloma. Twenty-eight grams of tissue were removed. The patient's recovery was uneventful, and there was no recurrence during a period of ten years after the operation.

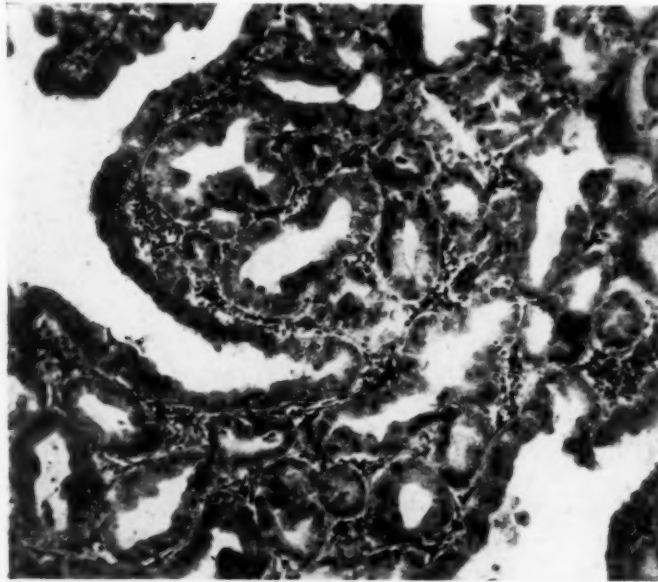


FIG. 3 (Case A39582).—High columnar epithelium with small nuclei; no mitosis. Non-malignant papilloma. X100.

MALIGNANT TUMORS OF THE THYROID

NON-MALIGNANT PAPILLOMA

Case IV (A95417). A woman, aged twenty-three, had had goiter for seven years previous to operation. Cysts were enucleated from the right lobe and isthmus. Forty-five grams of tissue were removed. There was no recurrence during seven years after operation.

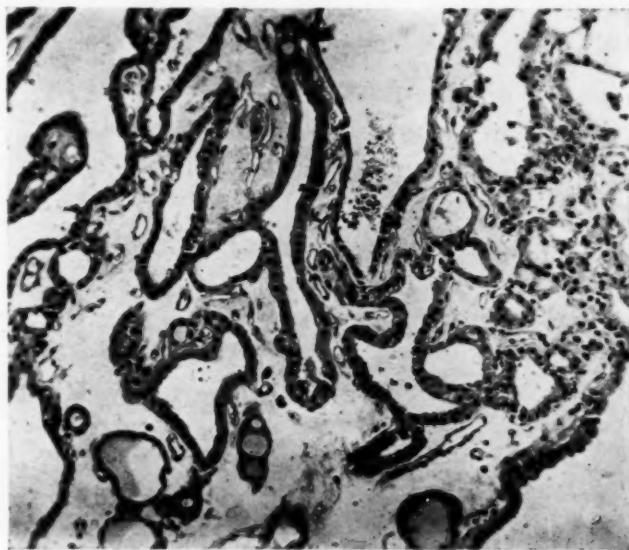


FIG. 4 (Case A95417).—Note clear hyaline centers of papillæ, small epithelial cells with shrunken nuclei without mitosis. Non-malignant papilloma. X100.

ADENOPAPILLOMA

Case V (A47855). A man, aged forty-nine, had had goiter for five years with rapid growth for one year. The right lobe and isthmus were extirpated for impending suffocation. Four hundred twenty-five grams of tissue were removed. Recurrence followed within one year; there were nodules in the scar, and hemorrhages apparently from the larynx. Death occurred eighteen months after the operation.

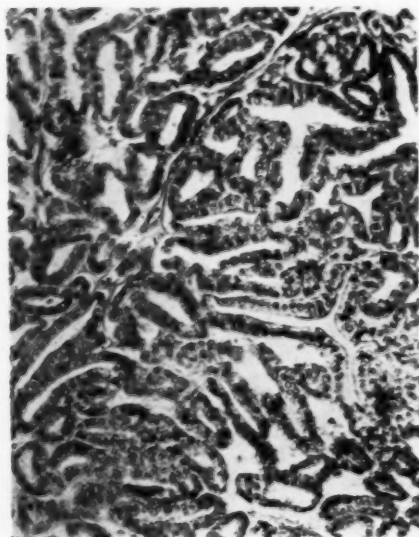


FIG. 5 (Case A47855).—Rapidly proliferating papilloma. X100.

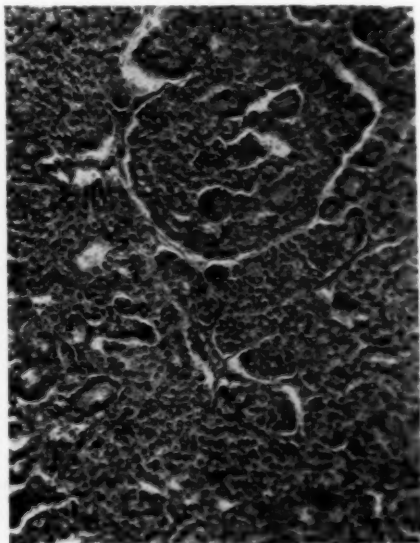


FIG. 6 (Case A47855).—Adenomatous area showing only slight tendency to papillae formation. Small embryonic cells with relatively large nuclei. Adenopapilloma, malignant. X100.

MALIGNANT TUMORS OF THE THYROID

ADENOPAPILLOMA (MALIGNANT)

Case VI (A94082). A woman, aged forty, had had goiter for sixteen years with accelerated growth for two years. A dense calcareous goiter was adherent to the trachea, and all the anterior muscles were involved. It was impossible to remove the entire growth. Fifteen grams of tissue were removed. X-ray treatments were given for four months, during which time the growth largely disappeared; it recurred three years after operation. The patient is alive and not suffering serious inconvenience six years after operation.

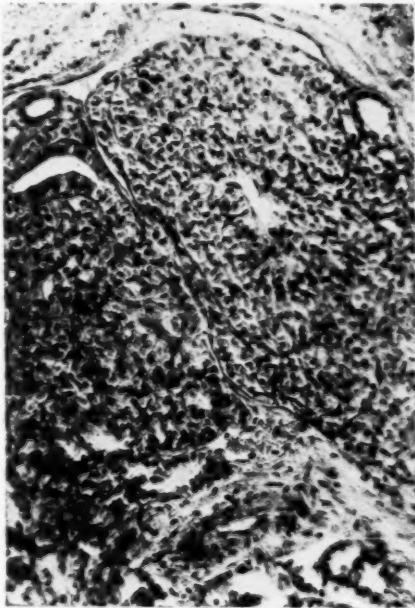


FIG. 7 (Case A94082).—A section at the base of the papillomatous area. The epithelial cells are evidently proliferating. X100.

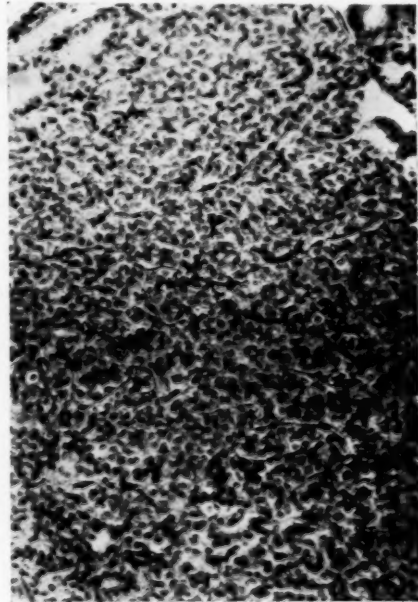


FIG. 8 (Case A94082).—Adenomatous area: small partly differentiated cells with relatively large nuclei separated into short irregular twisted cordons by thin-walled flat capillaries. Adenopapilloma, malignant. X100.

LOUIS B. WILSON

MEDULLARY CARCINOMA

Case VII (A16767). A man, aged forty-eight, had had goiter for five years; slowly growing for the last few months. The right lobe and isthmus were extirpated. Four hundred grams of tissue were removed. The patient was reexamined twenty-two months later, and then had obstruction and dyspnoea. A hard, nodular tumor five by five inches was found in the right thyroid region; it had grown rapidly for the last few months. The patient died two years after operation.

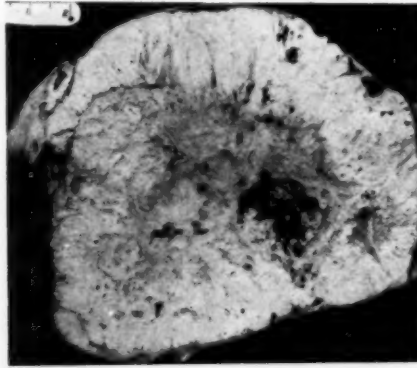


FIG. 9 (Case A16767).—A gross section through the tumor showing fibrous scar-like center with adenomatous subcapsular portion, and fibrous lines radiating from the center to the capsule. This arrangement is typical of the proliferating embryonic adenomas and suggests the origin of this medullary carcinoma from such a tumor. Medullary carcinoma.

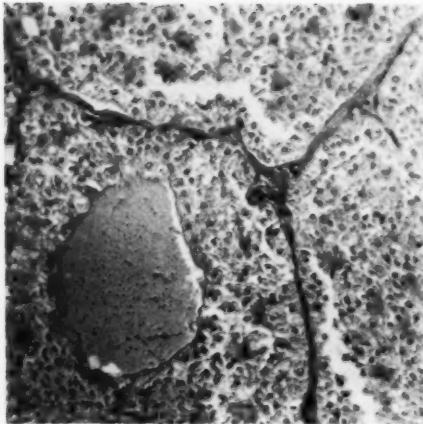


FIG. 10 (Case A16767). A section from the fibrous area showing large epithelial cells in small acini, degenerating. X100.

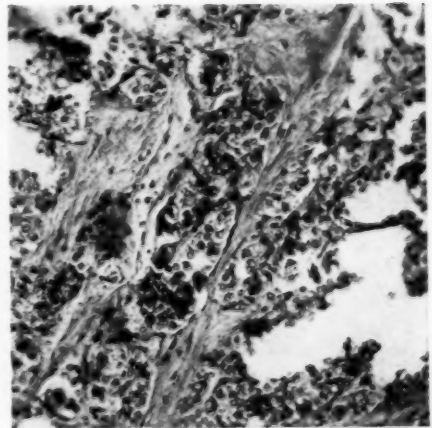


FIG. 11 (Case A16767).—A section through the soft portion of the tumor. Portions of three large acini shown densely crowded with medium-sized epithelial cells which are breaking down; one area of colloid. X100.

MALIGNANT TUMORS OF THE THYROID

MEDULLARY CARCINOMA

Case VIII (A44143). A man, aged forty-one, had had a hard goiter for twenty years; it had enlarged rapidly during the last year. An adenoma of the isthmus, which invaded both lobes, penetrated at the base, and involved the muscles; the mediastinum was enucleated. Three hundred five grams of tissue were removed. One month after operation a rapidly growing tumor recurred. The patient died two months after the operation.

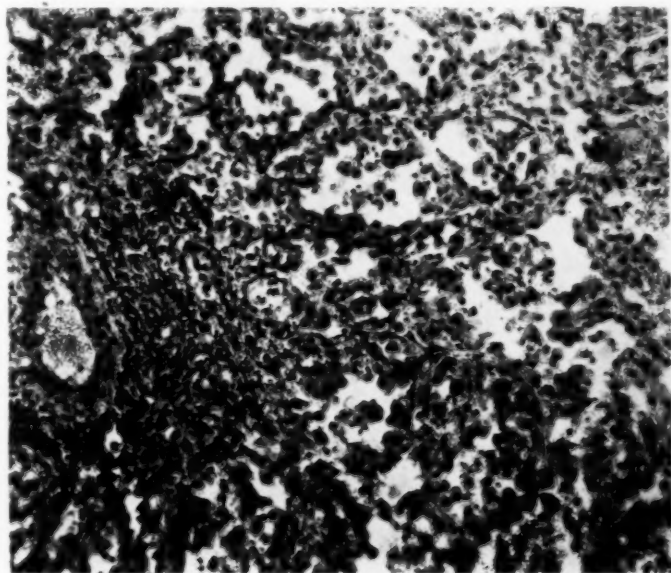


FIG. 12 (Case A44143).—A section through the soft portion of the tumor showing large proliferating and degenerating epithelial cells in loose acini. Medullary carcinoma. X100.

MEDULLARY CARCINOMA

Case IX (A109792). A man, aged sixty-five, had had goiter for twenty-two years; growing more rapidly for the past eight years. A clinical diagnosis was made of multiple adenomas, possibly malignant. The patient refused operation. He returned twenty-one months later, having used local applications. The tumor was slightly larger than before, inflamed and more fixed. The pyramidal and median lobes were resected. Three hundred ninety-five grams of tissue were removed. One month later a recurring growth was removed by the Percy cautery. The cautery was used again in one month, followed by radium treatment. The patient died three months after the first operation.

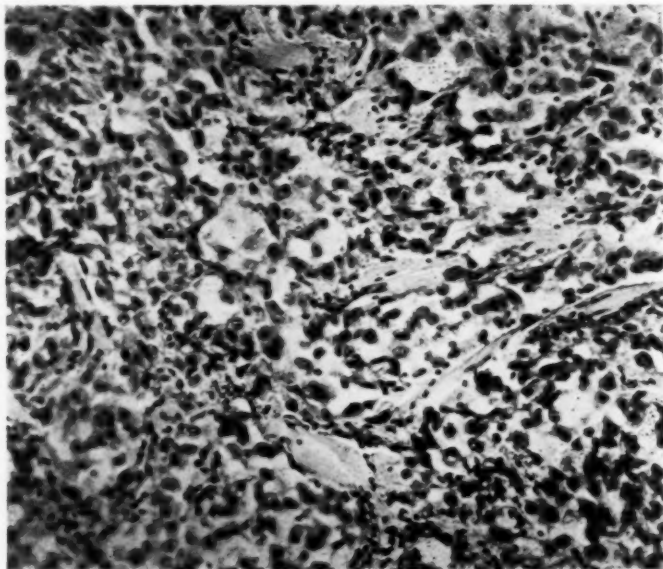


FIG. 13 (Case A109792).—Large epithelial cells evidently rapidly proliferating, some acinar arrangement. Medullary carcinoma. X100.

MALIGNANT TUMORS OF THE THYROID

ADENOMEDULLARY CARCINOMA

Case X (A119660). A woman, aged forty-three, had had goiter for fourteen years with accelerated growth for five years. An adenoma of the isthmus which invaded both lobes was removed. Two hundred forty grams of tissue were removed. The tumor recurred two and one-half years after the operation. The patient died three years after the operation with extensive metastasis in the lungs.



FIG. 14 (Case A119663).—A gross section through a portion of tumor showing typical proliferating adenoma arrangement. Adenomedullary carcinoma. X100.

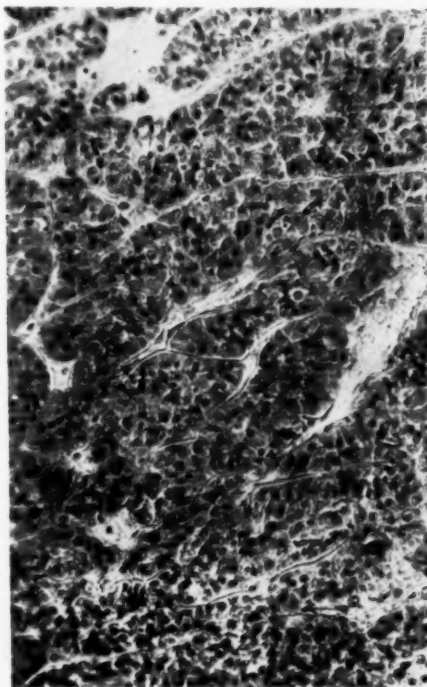


FIG. 15 (Case A119660).—A section through the softer portion of tumor showing large epithelial cells proliferating and degenerating lying in well-marked cords and follicles. The character of cells indicates the beginning medullary type. Arrangement shows plainly adenomatous origin. X100.

LOUIS B. WILSON

ADENOMEDULLARY CARCINOMA

Case XI (A96681). A woman, aged thirty-four, had had goiter for eight years. A partial thyroidectomy had been performed twice elsewhere during the last two years. No pathologic examination of the tissue removed at these operations had been made. There had been a recent rapid growth. All of the right lobe except the superior pole was removed. Seventy-two grams of tissue were removed. Three months later a rapidly recurring growth including tissue from behind the larynx was removed by excision and cautery, and a tracheotomy performed. Death occurred one month later. Extensive metastasis was found to the lungs, lymphatics and left sternoclavicular articulation.

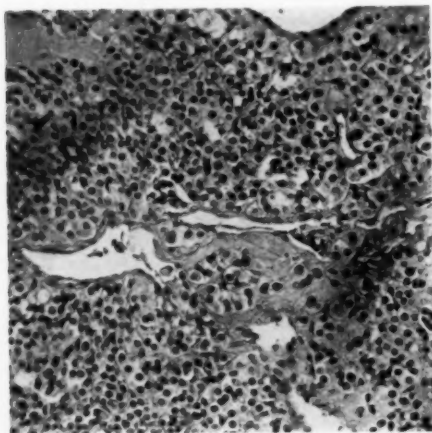


FIG. 16 (Case A95581).—A section through the more solid portion of the thyroid tumor. Large epithelial cells showing traces of alveolar arrangement. X177.

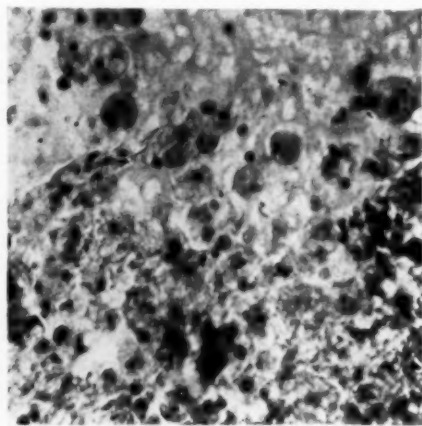


FIG. 17 (Case A95581).—A section through the soft portion of the recurring tumor showing a "medullary" type of cells. X22).



FIG. 18 (Case A96681).—A gross section through the lungs. Light areas show metastasis. Adenomedullary carcinoma.

MALIGNANT TUMORS OF THE THYROID

SCIRRHOUS CARCINOMA

Case XII (G6848). A man, aged forty-eight, had noticed gradual trouble in the right side of his neck and in his tonsils for the past year. The right lobe of the thyroid, the sternomastoid, and omohyoid muscles, the internal jugular and the lymphatics on the right side were removed. One hundred grams of tissue were removed. Four years after the operation the patient wrote, "I think the operation could not have been better; neck has not swelled or bothered me since. Now have asthma more or less." The patient died five years after the operation with involvement of the lungs.

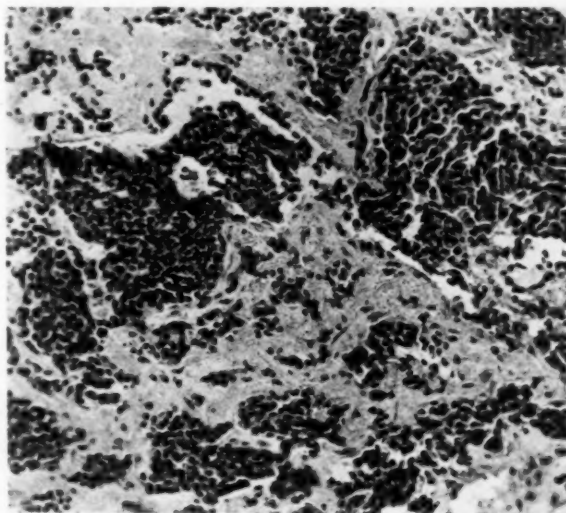


FIG. 19 (Case G6848).—A section through a hard portion of the tumor in the thyroid, showing epithelial cells much condensed by fibrous connective tissue. Scirrhous carcinoma. X100.

SCIRRHOUS CARCINOMA

Case XIII (A68082). A man, aged twenty-six, had had a small tumor on the right side of his neck since childhood; it had enlarged in the past two years. Three years before it had been diagnosed goiter by his physician. He had been dyspnoeic during the past year. On exploration a large intrathoracic tumor was found which could not be removed and tracheotomy was performed. Twenty grams of tissue were removed for diagnosis. The patient died three days after the operation. Necropsy revealed a tumor involving the trachea, which was reduced to ribbon shape and extended into the mediastinum to the pericardium. The mediastinal glands were involved. There were numerous metastatic nodules in the liver and spleen.



FIG. 20 (Case A68082).—The trachea opened from behind, showing small carcinomatous nodules under the mucosa.

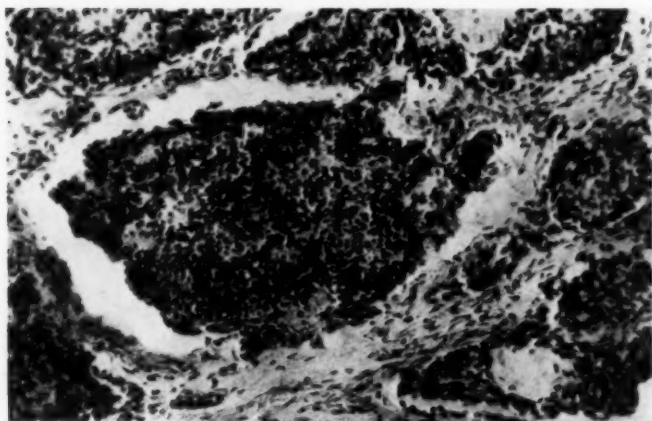


FIG. 21 (Case A68082).—Epithelial cells condensed by fibrous connective tissue. Scirrhous carcinoma. X100.

MALIGNANT TUMORS OF THE THYROID

SCIRRHOUS ADENOCARCINOMA

Case XIV (A89086). A woman, aged thirty-four, had had goiter for twenty years, with accelerated growth for five years but no serious symptoms until seven months before. The left lobe of the thyroid was extirpated. Twenty-five grams of tissue were removed. The patient died nine months after the operation from recurrence.

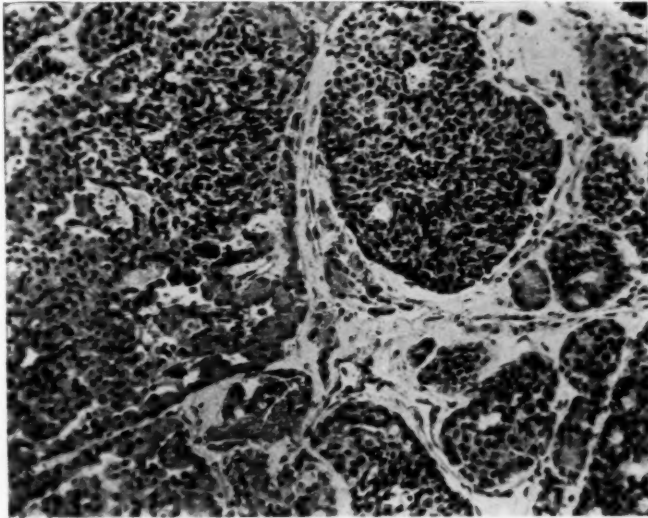


FIG. 22 (Case A89086).—Epithelial cells in crowded acini; nuclei though distorted resemble those in embryonic cells, suggesting derivation from proliferating embryonic adenoma. Scirrhous adenocarcinoma. X100.

MIXED-CELL SARCOMA

Case XV (A19893). A woman, aged thirty-nine, had had goiter for seven years, with rapid growth during the last six months. A firm, almost hard, spherical, movable enlargement was palpated in the right lobe of the thyroid. The tumor, which was about 7 cm. in diameter, was attached to the trachea and had infiltrated through the capsule. One hundred thirty-six grams of tissue were removed. Six centimeters of the right internal jugular were removed with the tumor. Death occurred six months after the operation.

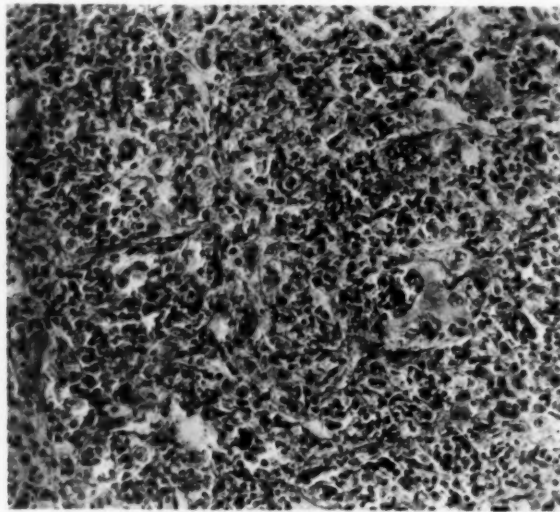


FIG. 23 (Case A19893).—Mixed, round, spindle and giant cell sarcoma. $\times 100$.

MALIGNANT TUMORS OF THE THYROID

SPINDLE CELL SARCOMA

Case XVI (A59130). A man, aged fifty-six, had had goiter for twelve years, with accelerated growth for about three years. The left lobe and isthmus were extirpated; the tumor was infiltrating the muscle. Two hundred twenty grams of tissue were removed. The patient died two months after the operation.



FIG. 24 (Case A59130).—A section through a gross specimen, showing solid and spongy areas.

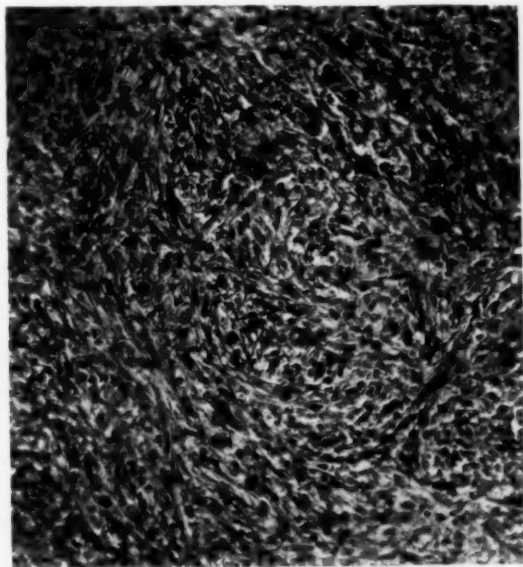


FIG. 25 (Case A59130).—A section through a solid area showing spindle-cell sarcoma with a few round cells. X100.

ALVEOLAR SARCOMA SUGGESTING EPITHELIAL RELATIONSHIP

Case XVII (A138004). A woman, aged sixty-four, who did not give a history of previous goiter, had noted a rapid growth of the thyroid for three months. At exploratory operation, a small piece of tissue was removed for diagnosis. Death occurred four months after the operation.

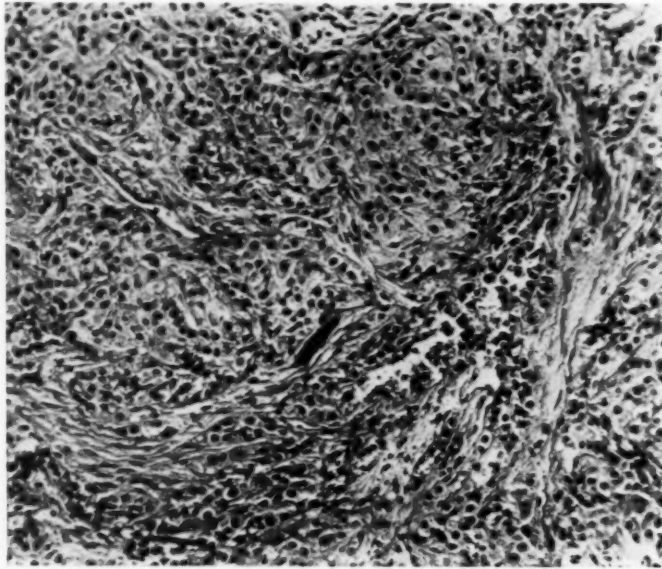


FIG. 26 (Case A138004).—Alveolar sarcoma. X100.

MALIGNANT TUMORS OF THE THYROID

CARCINOMA SARCOMA

Case XVIII (A163873). A woman, aged fifty-two, had had goiter for thirty-seven year with accelerated growth for one year. A total thyroidectomy was performed for advanced malignant tumor, involving the right lobe of the thyroid. Two hundred ten grams of tissue were removed from the right lobe. The growth recurred nine months after the operation.

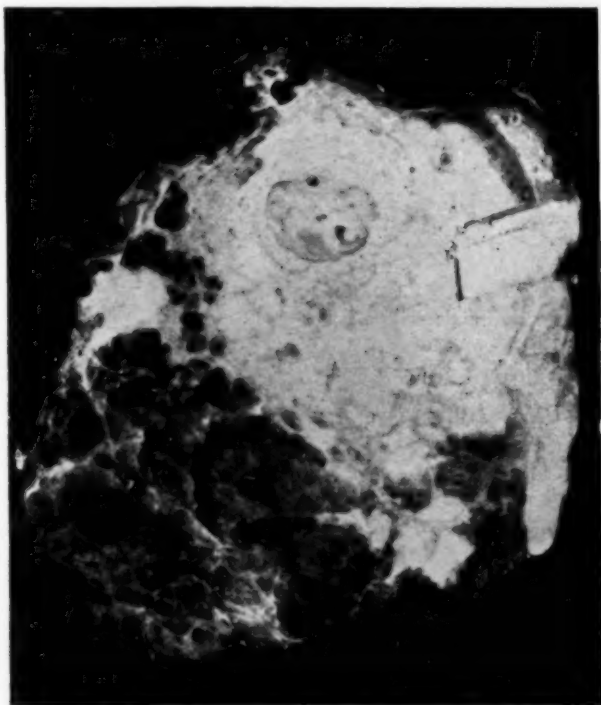


FIG. 27 (Case A163873).—A section through the gross specimen showing a tumor developing in the adenoma in the old colloid goiter.

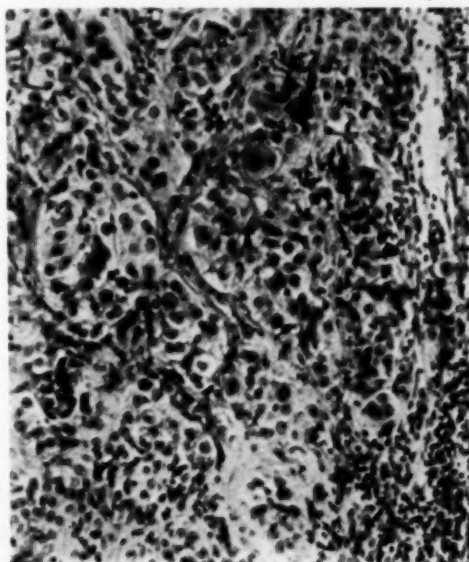


FIG. 28 (Case A163873).—A section through the portion of solid tumor near the capsule, showing proliferation of both epithelial and connective tissue elements. X100.

CARCINOMA SARCOMA

Case XIX (A57935). A woman aged sixty-three, had had very hard deep-lying tumors in the right and left lobes of the thyroid for four years. The entire thyroid gland was extirpated. Two hundred grams of tissue were removed. The patient remained apparently well for six years, then died within nine months of rapid recurrence with extensive metastasis.

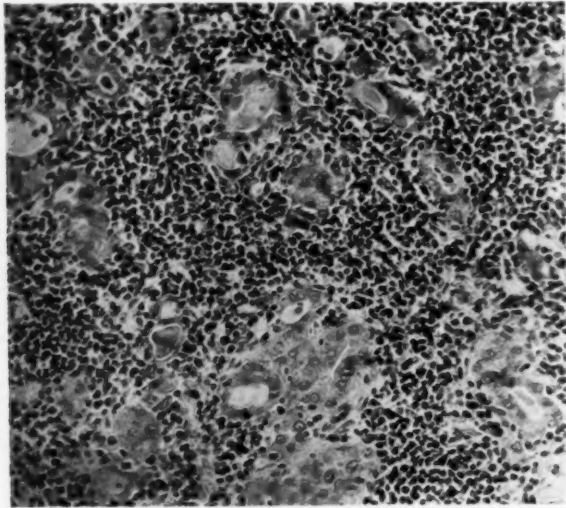


FIG. 29 (Case A57935).—A section through the edge of the tumor, showing proliferated epithelial cells which are now degenerating, and proliferation of connective tissue cells between the acini. Carcinoma sarcoma. X100.

MALIGNANT TUMORS OF THE THYROID

ROUND AND GIANT CELL ADENO-SARCOMA

Case XX (A32772). A man, aged seventy, had had goiter for sixteen years which had gradually enlarged for eleven years, remained stationary for three years, and then gradually enlarged for two years. A hard nodular goiter was enucleated from the left side. Two hundred twenty grams of tissue were removed. The growth recurred in two months and death occurred in four months.

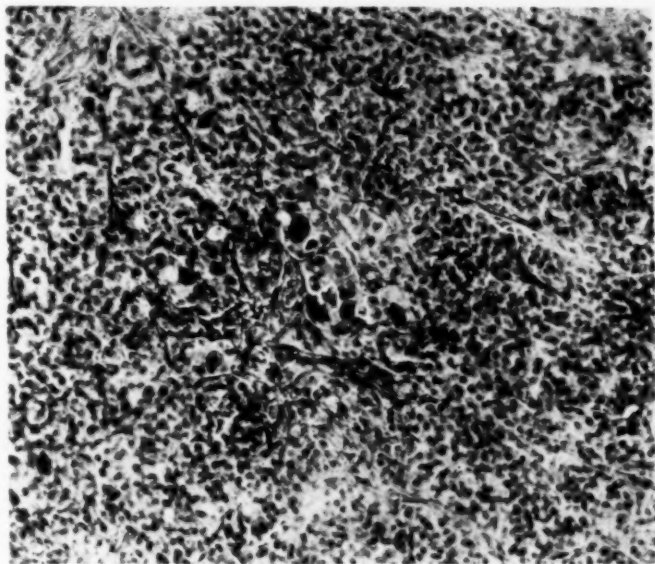


FIG. 30 (Case A32772).—Sarcoma composed of small round and giant cells; small round cells still showing marked evidence by their grouping of their origin as an embryonic adenoma. X100.

LOUIS B. WILSON

SMALL ROUND-CELL SARCOMA

Case XXI (A182791) A woman, aged fifty-nine, had had goiter for one year, with accelerated growth for two months. The entire right lobe and isthmus and all of the left lobe except a piece of gland half the size of a normal lobe which was left at lower pole were removed. One hundred sixty-five grams of tissue were removed from the right lobe; seventy grams were removed from the left. The patient was re-examined four months after the operation. She was dyspnoëic on exertion, worse during the last two months. Death occurred two years after the operation from "trouble with lungs"; no necropsy.



FIG. 31 (Case A182791).—A section through the more solid portion of the tumor, showing small areas of colloid thyroid (dark) here and there in the tumor.

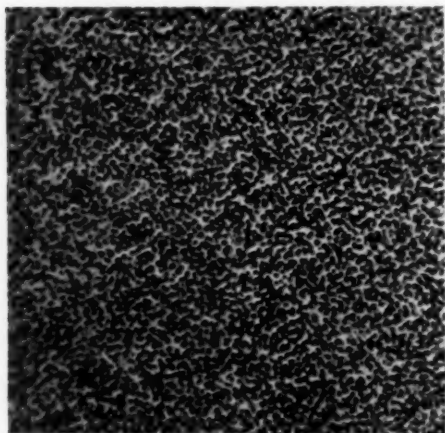


FIG. 32 (Case A182791).—Small round-cell sarcoma. In some areas cell grouping suggests that in embryonic adenomas. X100.

MALIGNANT TUMORS OF THE THYROID

SMALL ROUND-CELL SARCOMA

Case XXII (A30889). A woman, aged fifty-two, had had a slowly growing goiter for one year. The entire gland was extirpated. Eighty-six grams of tissue were removed. The growth recurred two months later and was treated by X-ray. There was some evidence of metastasis five and one-half years after operation. Death occurred six years after operation.

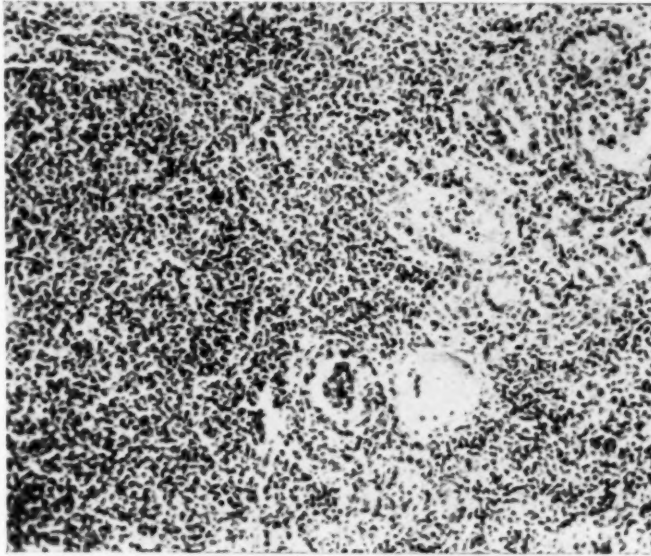


FIG. 33 (Case A30889).—Small round cells here and there in groups suggesting partially differentiated embryonic adenomatous tissue. Small round-cell sarcoma. X100.

ADENOCARCINOMA

Case XXIII (P5459) A woman, aged sixty-six, had had goiter for thirty years, rapidly growing for four months. She was dyspnoeic; had mucus in the trachea that was hard to get up. A complete thyroidectomy was performed. Three hundred eighteen grams of tissue were removed. Death occurred one year after the operation.

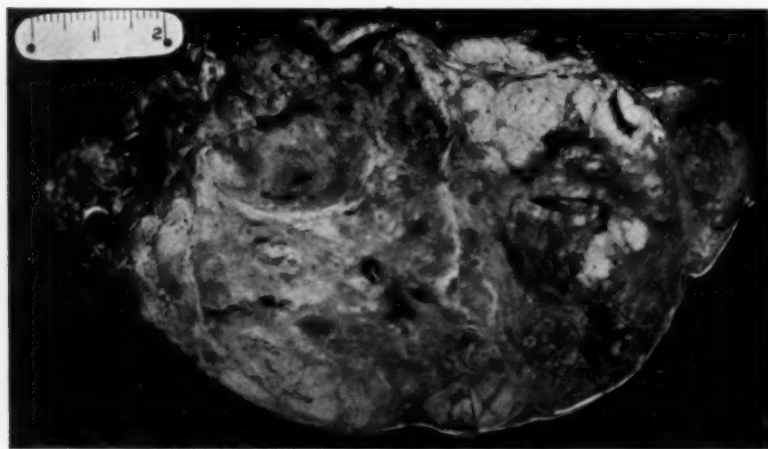


FIG. 34 (Case P5459) —A section through the gross specimen, showing encapsulated mass of tumor tissue (light) advancing into colloid areas (dark).

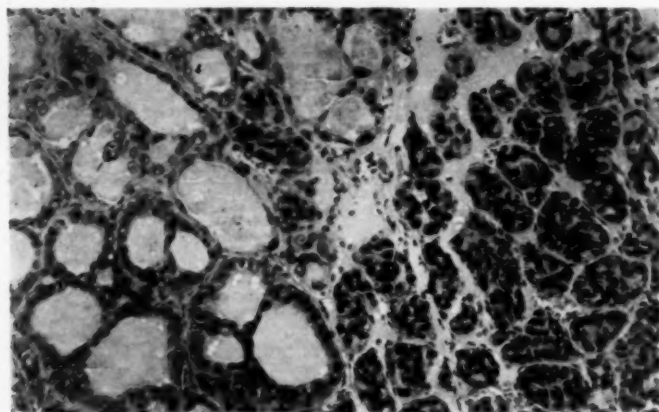


FIG. 35 (Case P5459).—Edge of the tumor area showing adenocarcinoma in colloid adenoma. X100.

MALIGNANT TUMORS OF THE THYROID

ADENOCARCINOMA

Case XXIV (A26084). A woman, aged thirty-eight, had had a gradually growing goiter for four years. An adenoma was enucleated from the left lobe of the thyroid. Forty-eight grams of tissue were removed. Six years after the operation a rapidly growing recurrent tumor developed. Death occurred six and one-half years after operation from involvement of the larynx and trachea.

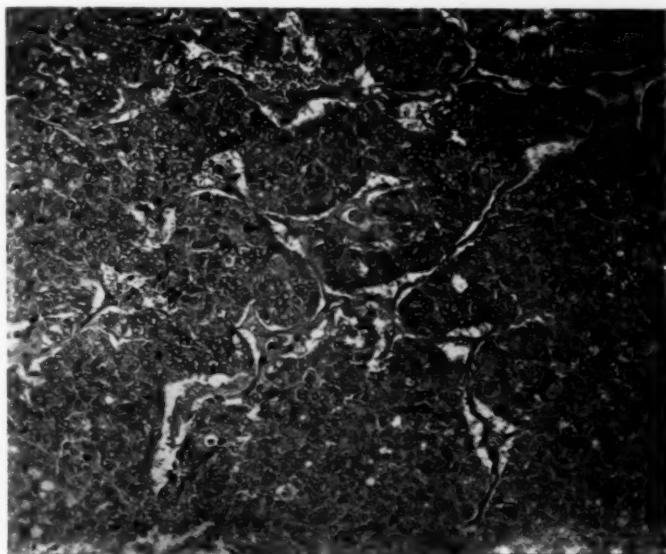


FIG. 36 (Case A26084).—Carcinoma composed of adult epithelial cells in some places arranged in irregular whorls like those of proliferating embryonic adenomas. X100.

ADENOCARCINOMA

Case XXV (A91931). A man, aged fifty-seven, had had goiter for eighteen months. Thyroidectomy was performed; the trachea was freed, and a portion of the right lobe removed. Twenty grams of tissue were removed. The tumor which originated in and involved mainly the right lobe, had perforated the muscles and involved the sternomastoid muscle on the right side. X-ray treatment was given for three months, then the cancer eroded through the skin. The patient went to a "plaster specialist." Several severe hemorrhages occurred after the "plaster treatment." The patient died one year after operation.

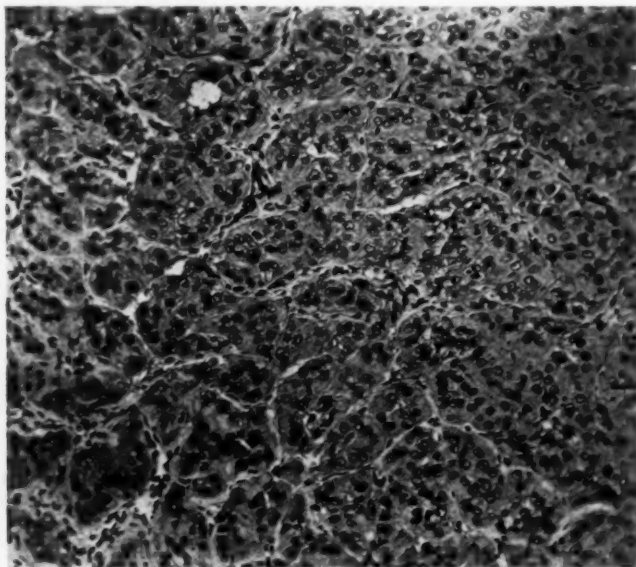


FIG. 37 (Case A91931).—Adenocarcinoma composed of adult epithelial cells arranged everywhere in masses typical of embryonic proliferating adenomas. X100.

MALIGNANT TUMORS OF THE THYROID

MALIGNANT ADENOMA

Case XXVI (A23842). A woman, aged twenty-seven, had had goiter for ten years; it had grown gradually until about two months before when it began to increase more rapidly. A nodular tumor of the right lobe was extirpated. One hundred ninety grams of tissue were removed. The patient returned for examination four years after operation with recurrence of a tumor in the right lobe. The entire right lobe of the thyroid, which was fixed to the trachea and cricoid cartilage and involved the larynx was removed. One hundred grams of tissue were removed. Two and one-half years after the second operation the patient reported that the gland was enlarging slowly; she was growing weaker and showing some cachexia. Death occurred eight years after the first operation from tracheal involvement and probably metastasis to the lungs.



FIG. 38 (Case A23842).—A section through a gross specimen showing the ordinary type of proliferating adenoma with gland tissue in the center of the nodule replaced by connective tissue.

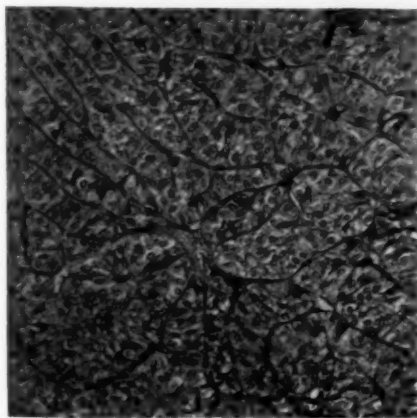


FIG. 39 (Case A23842).—A section through the solid area of a tumor near the capsule, showing adult epithelial cells in lobules and long narrow bands corresponding to Langhans' description; mitosis in cells. X100.

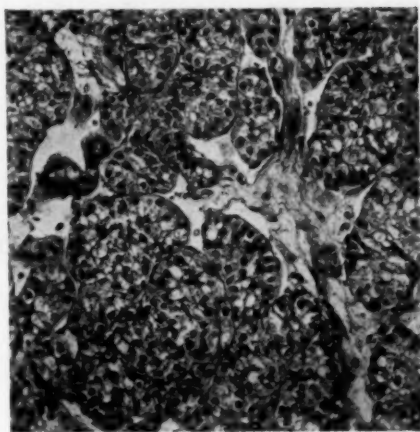


FIG. 40 (Case A23842).—A section through a looser area. Lobules arranged in short whorls; cells show colloidal though definite acini are absent. X100.

PROLIFERATING EMBRYONIC (FETAL) ADENOMA, MALIGNANT

Case XXVII (A164145). A man, aged fifty-one, had had goiter for seventeen years with accelerated growth for five years. There was slight hyperthyroidism. An adenoma was enucleated from the right lobe of the thyroid. The gland was densely fixed posteriorly. Four hundred eighty grams of tissue were removed. X-ray and radium treatment were given for one month following the operation. Five months after the operation, examination revealed considerable enlargement of the right lobe. The patient was alive and well when last heard from two years after the operation.

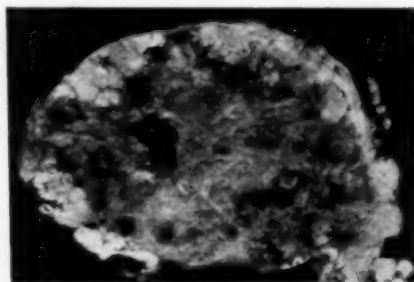


FIG. 41 (Case A164145).—A section through the gross specimen showing extensive hyaline and fibrous degeneration. Compare this with Figures 38, 44, and 46.

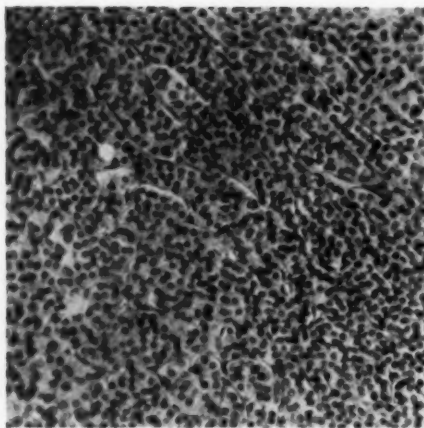


FIG. 42 (Case A164145).—A section through the dense portion of the adenoma immediately under the capsule. Note small embryonic cells arranged in lobules and bands with a very small amount of stroma (thin-walled blood-vessels) between. X100.

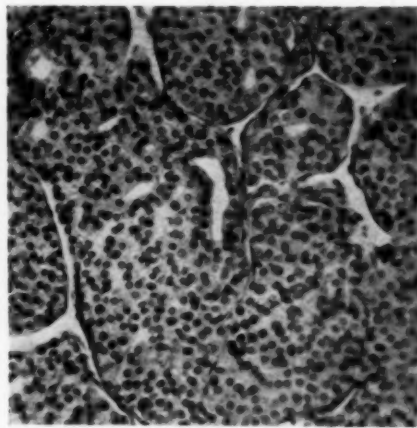


FIG. 43 (Case A164145).—A section from an area farther from the capsule than that shown in Figure 42. The embryonic cells are larger and in larger lobules, marked-off by cleft-formed blood-vessels. X100.

MALIGNANT TUMORS OF THE THYROID

PROLIFERATING EMBRYONIC (FETAL) ADENOMA, MALIGNANT

Case XXVIII (A155669). A man, aged forty-five, had had goiter for twenty years with accelerated growth for two years. Two partial thyroidectomies had been performed elsewhere, twelve and seven years before respectively. No data were obtainable concerning the character of the removed tissue. A partial thyroidectomy was performed. Forty-five grams of tissue were removed. Four months later the home physician reported that the patient was in good health and working every day. One year after the operation serious pressure on the trachea was reported. Death occurred one year and four months after the operation, following tracheotomy for pressure made by a large tumor of the thyroid. No necropsy was made and no data were obtainable concerning the histology of the tumor or of possible metastasis.

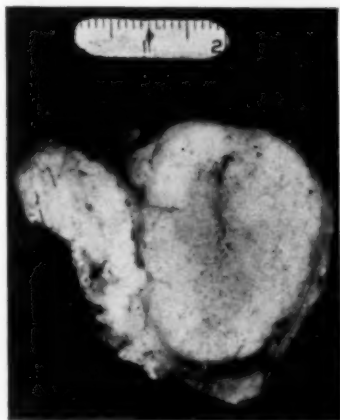


FIG. 44 (Case A155669).—A section through the small adenoma removed at the third operation (the first in the Mayo Clinic). The entire nodule made up of actively growing tissue.

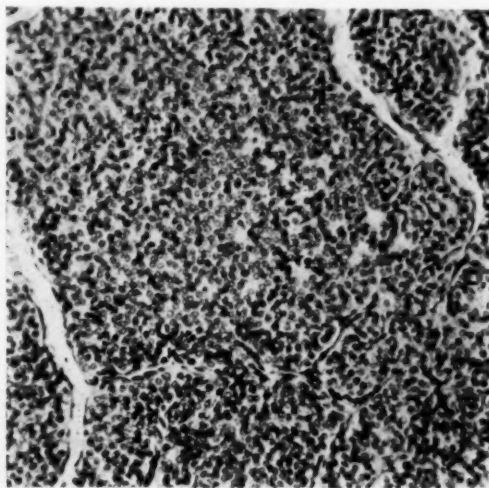


FIG. 45 (Case A155669).—A section through the tumor showing proliferating embryonic epithelium in some areas arranged in lobules. X100.

PROLIFERATING EMBRYONIC (FETAL) ADENOMA

Case XXIX (A91228). A man, aged twenty-six, had had a slow growing goiter for three years. Thyroidectomy was performed; a substernal goiter was partially removed. Five hundred fifty grams of tissue were removed. The patient was reexamined one year later. Goiter had recurred seven months after the first operation, producing marked obstruction during the last three months. A second operation was performed one year after the first; death occurred one year and eight months later.



FIG. 46 (Case A91228).—A section through the gross specimen. Almost the entire tumor is composed of rapidly growing tissue.

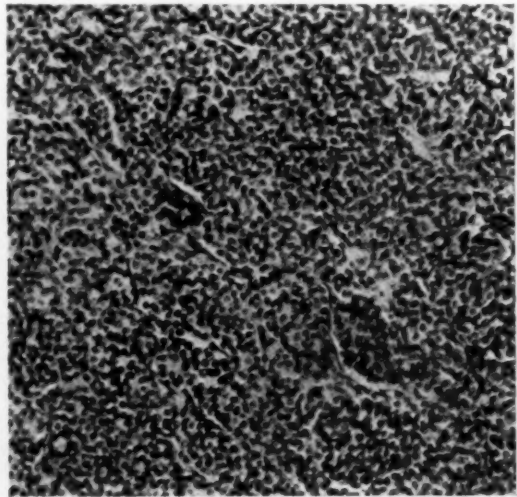


FIG. 47 (Case A91228).—A section through the tumor near the capsule; embryonic cells are arranged in feebly demarcated lobules. X100.

MALIGNANT TUMORS OF THE THYROID

PROLIFERATING EMBRYONIC (FETAL) ADENOMA, FIBROUS DEGENERATION

Case XXX (A23200). A woman, aged thirty-seven, had had goiter for twenty-nine years. A hard tumor of the right lobe of the thyroid was enucleated. The center of the tumor was broken down. One hundred eight grams of tissue were removed. The patient was reexamined seven years after the operation. The left lobe of thyroid was slightly enlarged. There were no symptoms. The patient was in excellent health eleven years after the operation.

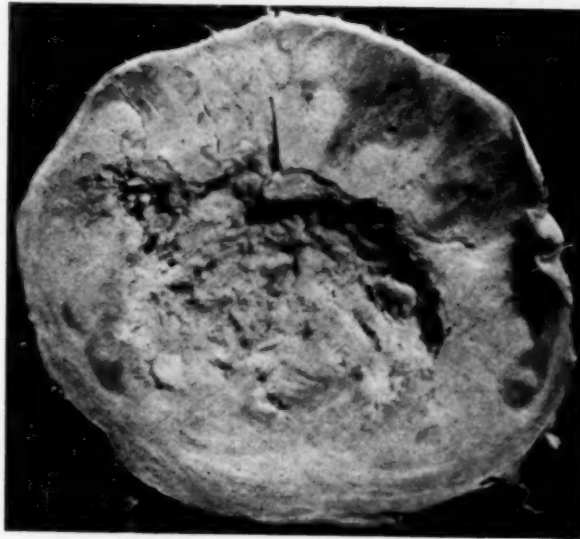


FIG. 48 (Case A23200).—A section through the gross specimen showing well encapsulated adenoma with degenerating center, marked fibrosis and some hyalinization, only small areas showing active growth.

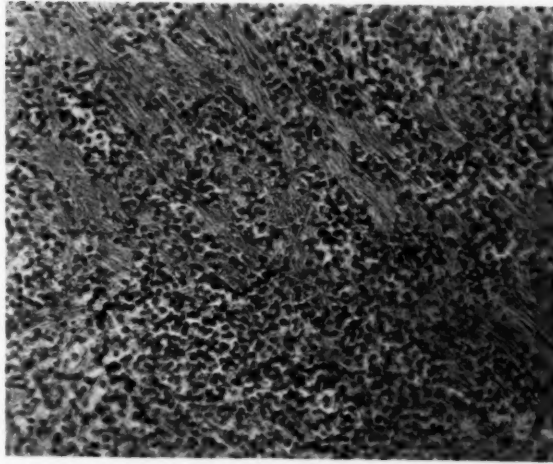


FIG. 49 (Case A23200).—A section through the edge of an apparently actively growing area. Embryonic epithelial cells enmeshed in fibrous connective tissue, X100.

NON-MALIGNANT ADENOMA

Case XXXI (A28462). A woman, aged sixty-five, had had a gradually growing goiter for thirty years. A cystic adenoma of the left lobe was enucleated. Five hundred twenty-four grams of tissue were removed. The patient has remained perfectly well during the eleven years since operation.

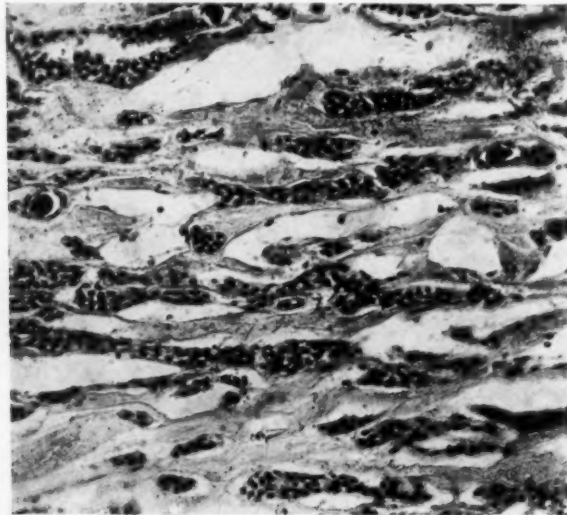


FIG. 50 (Case A28462).—A section through the outer portion of the thick cyst wall showing embryonic cells enclosed in heavy bands of fibrous connective tissue. X190.

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Case XXXII (A77623). A woman, aged forty-one, had had goiter for fifteen years without recent accelerated growth. A cystic adenoma of the right lobe was enucleated. Fifty grams of tissue were removed. The patient reports that she is in perfect health with no local recurrence of tumor up to eight years after the operation.

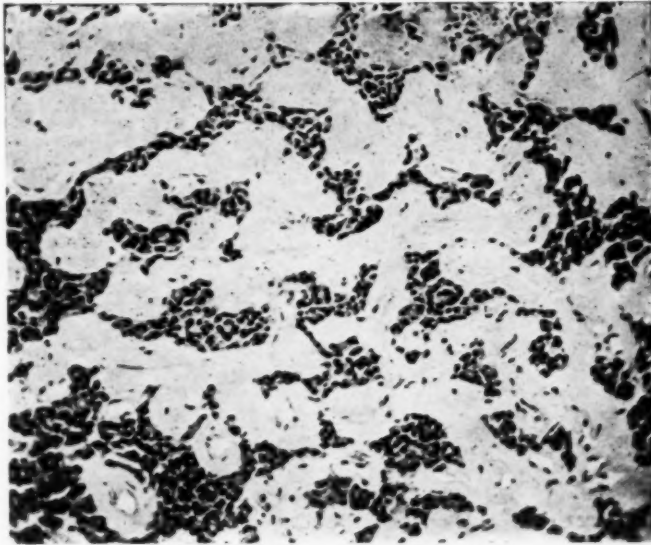


FIG. 51 (Case A77623).—Small embryonic cells in the broad bands of hyaline connective tissue. X100.

NON-MALIGNANT CYSTIC DEGENERATING ADENOMA

Case XXXIII (A93491). A woman, aged twenty-two, had had goiter for two and one-half years. A cystic degenerating adenoma of the left lobe of thyroid was enucleated. Sixty grams of tissue were removed. The patient is in good health without local recurrence seven years after operation.

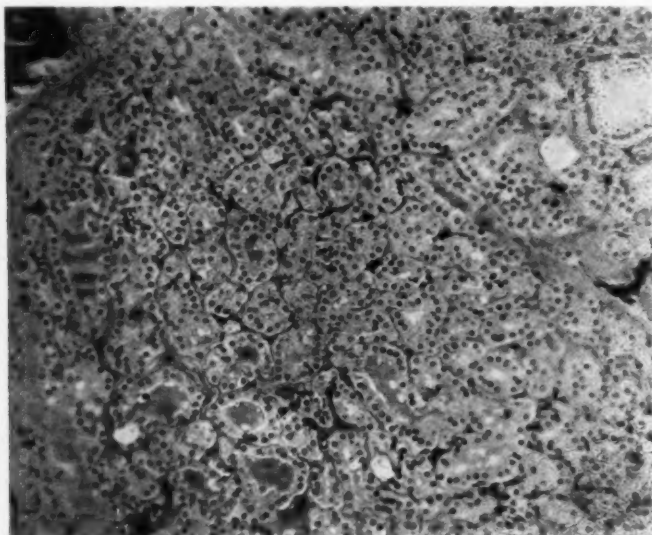


FIG. 52 (Case A93491).—A section through the wall of the cystic thyroid showing degenerating epithelial cells with granular protoplasm and shrunken nuclei arranged in well-defined lobules. X100.

MALIGNANT TUMORS OF THE THYROID

DEGENERATING CALCAREOUS ADENOMA

Case XXXIV (A100637). A man, aged forty-nine, had had goiter for one and one-half years. The right lobe and isthmus were extirpated and a calcareous adenoma involving almost the entire right lobe of the thyroid was enucleated. The right lobe projected a few inches beneath the sternum. One hundred forty grams of tissue were removed from the right, and sixty grams from the left. The patient is alive and well with no local recurrence up to six years after operation.

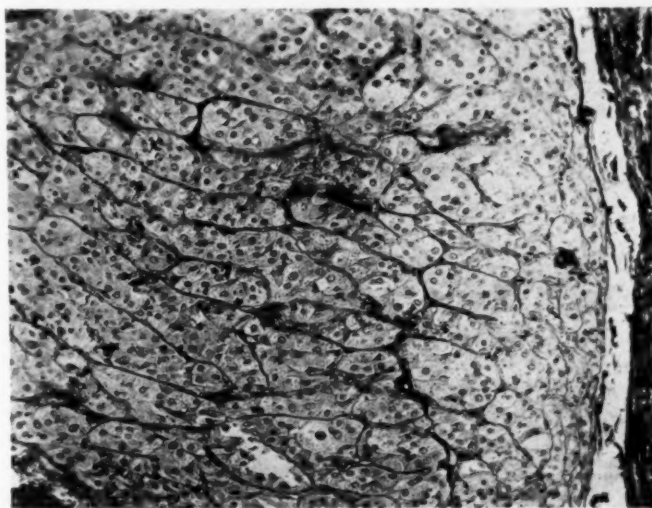


FIG. 53 (Case A100637).—A section through the periphery of the adenoma, including the capsule, near the calcified area, degenerating epithelial cells in well-marked lobules. X100.

DOUBTFUL

Case XXXV(A30296). A woman, aged twenty-eight, had had goiter for twenty-one years. It had not caused trouble until six years before. The growth had been rapid during the past two years. She had lost ten pounds in weight in the past year. The right lobe and isthmus were extirpated. One hundred fifty-six grams of tissue were removed. The patient returned for examination eight months after the operation. The goiter had markedly increased in size. The left lobe was resected. One hundred twenty grams of tissue were removed. The patient was examined five months after the second operation. She was complaining of choking, palpitation and dyspnoea, and had lost weight during the last week. Two and one-half years after the second operation she reported that she was the same as when last examined, still had a choking feeling but was not losing weight. Seven years after operation she was still having trouble with breathing, but felt better. Ten years after operation she reported no definite symptoms of recurrence; her general health as good.

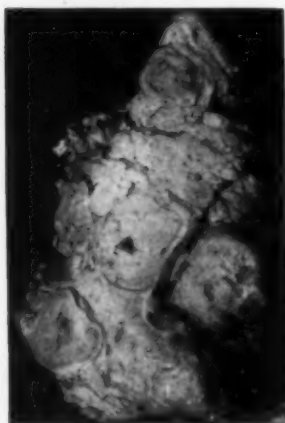


FIG. 54 (Case A30296).—A section through the right lobe of the thyroid, showing small adenomas included in apparently normal tissue.

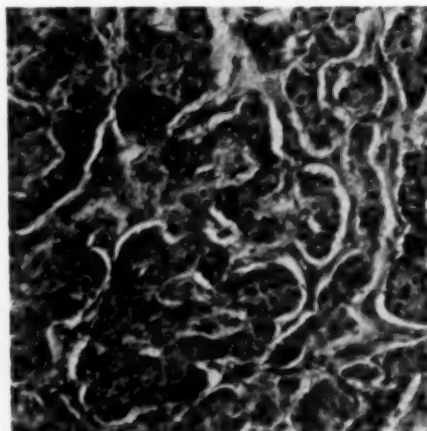


FIG. 56 (Case A30296).—A section through another small adenoma shown in Figure 54, showing partially differentiated embryonic epithelium in lobules between heavy bands of fibrous connective tissue. At first sight this looks like an infiltrated carcinoma. X100.

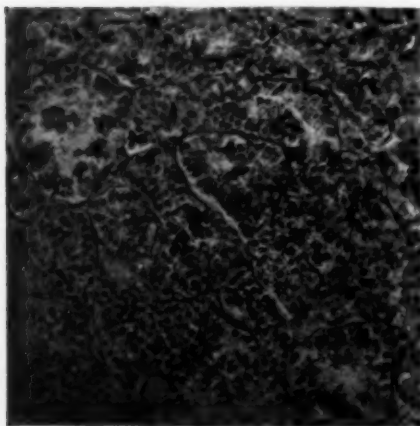


FIG. 55 (Case A30296).—A section through one adenoma shown in Figure 54, showing partially differentiated embryonic epithelium in well marked lobules, several of which contain colloid. X100.

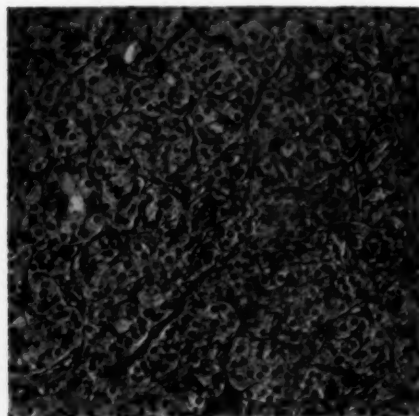


FIG. 57 (Case A30296).—A section through an adenoma removed at the second operation, fairly well differentiated embryonic epithelium arranged in lobules with well-marked vessels between. X100.

MALIGNANT TUMORS OF THE THYROID

PROLIFERATING ADENOMAS (WUCHERENDE STRUMA, LANGHANS)

A careful study of a large series of tumors of the thyroid leads inevitably to the conception of the very important part played by proliferating adenomas as the starting point of malignant tumors of finally varying histologic types. This has been shown in the preceding illustrations of specimens from illustrative cases. We are indebted to Langhans for the first detailed description of proliferating adenomas, although they had been observed previously by von Eiselsberg, Erdheim and many others. Langhans' description is so good that one cannot do better than to repeat it in part. The reader should compare the description with the preceding illustrations, particularly Figures 41 to 49 for embryonic types and Figures 36 to 40 for more differentiated types.

"Microscopically wucherende Struma forms large encapsulated, roundly oval or somewhat flat nodules which may reach a diameter of ten or fifteen centimeters or more. The surface is smooth or has flat projections which are attributable to its lobular structure. The lobules have a diameter of one to two centimeters and are divided from each other directly under the capsule by penetrating fibrous septa; toward the interior they often run together; the septa become perforated. Sometimes they (the septa) are very little developed in the periphery and are suggested only by indentations. In the centers of the nodules there are very often found more or less extensive loosely built connective tissue, somewhat stellate cicatrices. The neoplastic tissue is soft, often hypertrophic, of only medium transparency, and according to the blood content gray, red or pale. The surface of the cut section is smooth or slightly granular.

"The epithelial masses, in fifteen micron sections, show uniform cloudy, finely granular protoplasm with very dense round nuclei. Red outlines between the nuclei are to be seen only in places where they are further separated from each other. In thinner sections the cell outlines can be seen more easily, particularly with oil immersion lenses. The nuclei are round or slightly oval; the smaller ones measure six to eight microns, the larger ones ten and often fifteen microns. The latter usually show a distinct eosin-red nucleolus. The number of chromatin granules and threads is moderate. The nuclei in general are very numerous and are in contact with each other or separated by only a small fraction of their own diameters. There are also, not rarely, small dark nuclei which are usually lying singly between the other nuclei in varying numbers in the younger parts of the tumor as well as in the center in which they are even more frequent. In the region of the central loose "cicatrix" they are particularly abundant. They also show small clumped, poorly preserved mitoses.

"This nuclei-rich protoplasm is divided by septa, of only blood-vessels with sinus-like lumina, into smaller subdivisions. Between the septa and the epithelium is usually a space, probably the result of retraction of the protoplasm and collapse of the vessel walls. The subdivisions are polyhedral, roundish compartments or long band-like strips.

"The compartments are developed equally in all directions and have a diameter of 200 to 500 microns or even smaller. The majority are very regularly polyhedral with rounded corners. When sections are made radially or parallel to the capsule, the picture is the same. Therefore, they are not cord-like structures but are closed off from one another, in this respect being repetitions of normal thyroid vesicles on an enlarged scale.

"The band-like strips vary in their width more markedly than the compartments. Their width is usually less than the diameter of the compartments, 100

microns or less. Rarely have they even five densely arranged nuclei in their transverse diameter. All that are vertical to the capsule of the tumor are parallel to each other and can be easily traced from one to several millimeters; in the depths they are bound by transverse and oblique short branches.

"Compartments and bands may be present in combination. In such cases the bands have a very irregular course, being wound in all directions. The compartments may also be very various; they acquire semicircular sinuosities, become rosetted, or form papillæ-like and finger-like processes, coming out from one or several sides.

"The wide septa through the lobules are essentially fibrous.

"The septa between the epithelial compartments and bands have a very characteristic structure, which is always repeated in the metastasis, and because of that fact one may make a positive diagnosis from a small portion. They are made up of vessels with mere capillary walls. Often there is a loose fibrillary adventitia. Their form is likewise characteristic of these vessels. Only very rarely does one see the transverse section of the vessel or a round group of nuclei which might correspond to the endothelium of a collapsed vessel. Always visible luminae are cleft-formed and a good many of the polyhedral fields have on each side a single such lumen which gaps more or less widely. It is a markedly flattened sinus-like vessel resembling in some respects the blood-vessels of many sarcomas which also form small spindle-shaped or stellate clefts.

"Normally there may be smaller lacuna-like formations, 'sinusoids.'

"Stages are noted in which all of the previously solid compartments and bands have been changed to numerous small round gland vesicles. Often the vesicles are so dense that one can see the dividing septa only on high magnification. The septa having been changed they now are nucleolar instead of solid cell masses, a number of pure epithelial hollow spheres, each one of which is surrounded by only one layer of cells which lie more or less loosely near each other and without any vessel-containing septum between them. These pictures are particularly important.

"Colloid is found even in the gland vesicles; first in the form of a uniformly small line stained with eosin which outlines the protoplasm from the luminae, or in the form of a crescent which fills one-half or two-thirds of the lumen and with its pointed ends surrounds the entire periphery of the latter.

"Therefore, in the final stage of the process a new tissue is built that greatly resembles normal thyroid tissue and still more accurately resembles the tissue of a colloid Struma. Therefore, for wucherende Struma the first stage of the large solid cell masses and the final stage of groups of loosely lying gland vesicles without dividing septa are of great importance.

"I have assumed that the earlier stages are on the periphery and the later ones in the center of the nodule.

"In wucherende Struma we have a structure which in its regularity recalls a normal organ that is undergoing development; in the periphery the solid cell mass which disintegrates toward the interior into smaller cords and then into gland vesicles with one-layered epithelium and sometimes with colloid. We have, therefore, a tissue that is constantly being transformed. In addition we have a vessel with a characteristic form, arrangement, structure of walls and relationships to epithelium. In its architecture, wucherende Struma resembles the normal organ much more than it resembles carcinoma. . . .

"Is it formed, as is assumed to be the case in all malignant struma, on the basis of colloid nodule which suddenly begins to grow and increases in size and in consistency only as a result of severe stretching of the capsule? . . . I have seen no pictures which proved the origin of neoplastic cells from the epithelial cells of the gland vesicles. The general theory regarding the origin of malignant strumæ from accompanying colloid strumæ finds no basis in my investigations. The facts can

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be better understood if we assume that the wucherende Struma is such from the very beginning, that even in the earliest stages it consists of solid cell masses and that therefore it is to be traced back to that fetal period in which no gland vesicles had been formed and only solid cell masses are present. The process which takes place in wucherende Struma is certainly an incomplete parallel to that of the normal development of the thyroid. You may regard it as a delayed development from fetal rests."

BIZARRE GROWTHS IN DISTANT ORGANS

Previous observers have noted the occasional occurrence of malignant tumors composed of thyroid tissue growing in regions distant from the thyroid with total absence of any appearance of malignant tumor in the thyroid itself. The series of 290 cases herewith presented contains only one case of this kind (Case A300801), a woman, aged thirty, who came to the Clinic with a history of periodic hæmoptysis—"vicarious menstruation." Röntgenograms showed a right-sided mediastinal tumor about 7 cm. in diameter, not connected with the circulatory mechanism. A provisional diagnosis of intrathoracic thyroid was made. Operation was refused. Thyroxin was administered and very effectively controlled the hemorrhages for six months, after which time they recurred. The patient returned for examination one and one-half years after she was first seen. The tumor had materially enlarged and the patient was *in extremis*. The mediastinum was explored but no attempt was made to remove the growth. The patient died one week later. At necropsy a tumor of thyroid tissue of the embryonic adenoma type, 7 cm. in diameter, completely encapsulated, and encroaching on the right bronchus was found. The thyroid itself was normal except for one small degenerating adenoma, about 1 cm. in diameter, which did not appear to be malignant. Tumor tissue was not found elsewhere in the body. This was apparently an instance of the overgrowth of fetal tissue which had probably been misplaced into the lung in the embryo.

Not rarely the epithelial cells in the thyroid tissue of metastases are not in the same stage of development as that in the original tumor in the thyroid. A good illustration of this is found in Case A355859, of the series of 290 cases, a man, aged sixty-two, who came to the Clinic *in extremis* and died two days afterward. Necropsy showed the lungs, pleura, liver, and abdominal lymph nodes filled with extensive metastatic deposits of tumor tissue, the cells of which in their size, staining and arrangement resembled those in proliferating fetal thyroid. The thyroid itself was the site of an extensive malignant tumor, most of the tissue of which was composed of cells fairly well differentiated toward the adult type.

RECURRING THYROID TUMORS OF DOUBTFUL MALIGNANCY

The series of 290 cases contains three or four instances of young persons with rapidly proliferating tumors of the thyroid which histologically are either fetal or partially differentiated adenomas which recur rapidly and extensively and yet throughout long periods show no signs of metastasizing. (Case XXXV (A30296) Figs. 54 to 57). One should be warned in diagnosing the

condition shown in Figure 56, an infiltrating adenocarcinoma. The histology of the tumors in the other cases usually resembled that shown in Figures 55 and 57, but though recurrences have been frequent throughout periods of from eight to fourteen years, there is still no evidence of metastasis.

HYALINIZATION, FIBROSIS, CALCIFICATION AND HYDROPIC DEGENERATION

There can be no question but that many proliferating embryonic adenomas, which apparently start on their way toward malignancy, become impeded in their active overgrowth, reduced and finally degenerate, either by hyalinization, fibrosis, calcification or hydropic change. Good illustrations of this are seen in Cases XXX to XXXIV (Figs. 48 to 53), in which the relative amounts of connective tissue and parenchyma should be noted, as well as the cells with small, cramped, irregular nuclei without mitosis. The pathologist must take this possibility into account in his advice to the surgeon, but a proliferating adenoma in a patient of cancer age should not be considered benign unless the process of degeneration is very extensive and thoroughly overbalances the proliferation. The gross appearance of the tumor, the thickness and integrity of the capsule, the relationships of the capsule and fibrous septa to the parenchyma, the presence or absence of hyalinization, fibrosis, calcification and anemic or hydropic degeneration, the character and arrangement of the parenchymal cells, and the presence or absence of mitotic figures must all be taken into account.

SUMMARY

1. The paper presents an analysis of the literature and a summary of the data on 290 patients with malignant tumors of the thyroid who have been examined in the Mayo Clinic up to December 31, 1920.

2. Malignant tumors of the thyroid are much more frequent than is generally believed. Their correct clinical diagnosis is frequently missed (a) because they may have periods of development of from five to fifteen years and patients are not followed up long enough after operation, and (b) because not infrequently the tumor in the thyroid itself is relatively small and the character of metastasis is not determined, owing to the rarity of necropsies.

3. Pathologic diagnosis is difficult owing to the great variation in the histology of the tumor tissue and its resemblance to that of non-malignant processes.

4. There has been a marked failure of American surgeons to report in the literature their cases of malignant tumors of the thyroid; this should be corrected.

5. Insufficient observations are at hand for determining the geographic incidence.

6. The age incidence at the date of diagnosis is greatest in the fifth decade.

7. The distribution by sex is about one man to two women.

8. Patients usually seek medical advice on the occasion of recent rapid growth in a long-standing nodular tumor of the thyroid. Some give histories of slow continuous growth.

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9. Early thorough operations give a fair percentage of cures. Palliative operations in late cases with extensive local involvement are warranted.

10. Pathologic diagnosis must take into account the usual development of malignant tumors of the thyroid from proliferating embryonic adenomas.

11. A series of photographs of specimens, gross and microscopic, of thirty-five illustrative cases is presented with brief clinical and pathologic notes to serve as an atlas in assisting the pathologist in diagnosis.

12. The pathologist must be thoroughly familiar with the characteristics of proliferating adenomas, as first described by Langhans, in all their stages.

13. The pathologist must be on the lookout for the possible relationship of bizarre metastatic growths of tumors of the thyroid.

14. The pathologist, in his diagnosis for the guidance of the surgeon must consider the relative preponderance of proliferative and degenerative processes in the tumor, but a proliferating adenoma in a patient of cancer age should not be considered benign unless the process of degeneration is very extensive and thoroughly overbalances that of proliferation.

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CLINICAL EXPERIENCE WITH SYNERGISTIC ANALGESIA

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THE object of the research upon which this report is based was to find a more satisfactory method of inducing and maintaining analgesia and anæsthesia than exists at present. The fact that so many surgeons are using local, sacral, or spinal analgesia would seem proof to even the casual observer that the present methods are not satisfactory. From the introduction of ether and chloroform to the present time, surgeons and anæsthetists have been prone to contend for one anæsthetic or method, in preference to using a combination of anæsthetics or methods. This uncompromising attitude is well illustrated by the fact that in the Massachusetts General Hospital chloroform anæsthesia is practically never used, while in some parts of Scotland nothing but chloroform is used. If Sir James Y. Simpson had successfully demonstrated chloroform in the Massachusetts General Hospital and if Morton had successfully demonstrated the use of ether in Scotland, the situation would probably be reversed today. Advocates of "straight" nitrous oxide and oxygen anæsthesia are probably responsible for more deaths than are the advocates of any one anæsthetic or single method. Advocates of "straight ether" are entirely responsible for the unsavory reputation of ether. When a patient is saturated with nitrous oxide, with sufficient oxygen to maintain a satisfactory anæsthesia, he is bordering on or may be in the danger zone, and the next step will be respiratory arrest and death.

When a patient is saturated with warm oxygenated ether vapor (the safest and best method of administering ether) to the same degree of relaxation as one saturated with nitrous oxide and oxygen, he is much further removed from the danger zone than is the nitrous oxide and oxygen patient. If a sedative, such as morphine, is given as a preliminary, and if the anæsthesia is intelligently continued by the administration of either nitrous oxide and oxygen or ether, the patient is immediately removed much further from the danger zone. If now the patient is given the highest possible safe physiological dose of morphine (average adult grain) and the nitrous oxide and oxygen administered only for unconsciousness, the patient is separated from the danger zone by the second and third stages of anæsthesia, *i. e.*, the patient is held between A and C, as represented in the following chart, which shows the comparative safety of the methods just described.

SYNERGISTIC ANALGESIA.

Ether	Nitrous
anæsthesia	oxide and
alone.	oxygen
	anæsthesia alone.

A. Analgesia. B. 1st stage. C. 2nd stage. D. 3rd stage. E. Danger Zone. F. G.

- A. Commencement of anæsthesia.
- A. B. Analgesia.
- B. C. First or excitement stage.
- C. D. Second stage.
- D. E. Third or surgical stage—the usual stage in which operations are performed with inhalation anæsthesia.
- E. F. Danger zone.
- F. Respiratory arrest.
- G. Death.

The difficulties experienced with the usual inhalation anæsthesia are the lack of relaxation essential for many surgical procedures and the after-effect of nausea, vomiting, and gas pains, induced by the morphia. By the addition of magnesium sulfate to the preliminary morphine medication, a better relaxation is obtained and the nausea, vomiting, and gas pains are much reduced, if not entirely eliminated. If, on the other hand, no allowance is made by the anæsthetist, and if a state of anæsthesia is superimposed upon the state induced by preliminary medication, the patient is immediately plunged into the danger zone and possibly into a condition of shock from the inhalation anæsthetic. If the same degree of relaxation can be obtained with perfect safety by transferring the patient to the first stage of inhalation anæsthesia, thus removing him from the danger zone by two stages, one should not hesitate to abandon the established ideas of anæsthesia, and to accept the new method, *i. e.*, analgesia with unconsciousness. This condition is approximated by using morphine with magnesium sulfate as the analgesic, and inducing unconsciousness with nitrous oxide and oxygen.

In a previous paper¹, it was stated that when magnesium sulfate, 1 to 2 cc. (25 per cent. chemically pure), is used with morphine— $1/12$ to $3/8$ grain—instead of plain water, and given by hypodermic, the value of the morphine is increased 50 to 100 per cent., that is, "one hypodermic will do the work of from two to four." This was illustrated by stating that this hypodermic "will abolish pain for two, three, or four times as long as morphine given alone." This fact was obtained from bedside observation and can be easily verified by any one using magnesium salts 25 per cent. C. P. instead of sterile water with morphine for the relief of pain. But $1/8$ is not made equivalent to $1/6$ gr. or $1/6$ to $1/4$, or $1/4$ to $1/2$, or $3/8$ to $7/8$. By either increasing or repeating the dose of morphine with sterile water, its action is intensified but not prolonged, as when used with the magnesium salts. Furthermore, when the morphine with sterile water is repeated the possibility of nausea, vomiting, and gas pains is very greatly increased. Cushny² states, "Its (morphine) injection is occasionally followed by some nausea, which is much more fre-

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quently present during recovery from the drug." Evidently the effect of the magnesium salts abolishes this late untoward effect of morphine. It is well known that the preliminary administration of morphine abolishes the excitement or struggling stage and is a potent factor of safety, since over 90 per cent. of all deaths occur in the first five minutes of any inhalation anæsthesia. This preliminary medication renders the anæsthesia easier, smoother, and safer. The nausea and vomiting, as already stated, come on later, and sometimes are most disastrous. In favor of morphine, Cushny² states: "It has little direct action on the circulation in man; the blood pressure remains high. It is not contra-indicated in Bright's disease of the kidney, as it is not excreted in the urine." Meyer and Gottlieb³ state: "Perception of pain is diminished by doses which scarcely affect the motor centers, and which have no appreciable influence on the perception of ordinary sensations." These observers hold that "scopolamine is not an analgesic, and yet the combined administration of small doses of morphine and small doses of scopolamine, which by themselves produce hardly any effect, results essentially in an exaggeration of the effects of morphine." The synergism of morphine and scopolamine, morphine and atropine, and morphine with all the general anæsthetics is well known. The synergism of morphine, and magnesium sulfate is now partly understood. The prolonged analgesic effect, with absence of untoward effects, such as abdominal distention, headache, and post-anæsthetic vomiting, constitutes a distinct advance in the technique of anæsthesia.

The possible explanation of the increased value of morphine, may be that the magnesium simply holds the morphine in contact with the nerve tissues longer than the morphine can retain that contact alone; or we may assume that each of the agents used affects in a different way the same part of the central nervous system; or that each of them has an affinity for special nerves or centers, and that the combined result or synergism is safer and at the same time more powerful than that of any one of them used alone.

Whether the above explanations are or are not correct, the fact of the increased value of morphine with magnesium sulfate can be easily verified or disproved.

The following case illustrates the prolonged effect of morphine when used with minimum amounts of magnesium sulfate and is taken from the service of Dr. A. V. S. Lambert at the Presbyterian Hospital, New York, N. Y., as are all the other cases reported in this paper.

No. 46241 F.—Badly lacerated wound of leg, gas infection, opened wide December first, gastrocnemius severed.

December.

Duration, hours.

- | | | |
|------|--|----|
| 2nd. | 1.15 A.M. Morphia $\frac{1}{5}$ MgSO ₄ , 2cc. 25%, quiet until 5..... | 5¾ |
| | 6.15 A.M. Morphia $\frac{1}{12}$ MgSO ₄ , 2cc. 25%, no pain all day .. | 18 |
| | The magnesium was now discontinued. Morphine alone used. | |
| 3rd. | 1.30 P.M. Morphia $\frac{1}{6}$, pain in two hours..... | 2 |
| | 3.25 P.M. Morphia $\frac{1}{6}$, pain at 6.40 | 3¾ |
| | The magnesium was again added to the morphine. | |
| | 6.55 P.M. Morphia $\frac{1}{6}$, MgSO ₄ 25%, 2cc. No pain till next day. | 23 |

4th. 5.00 P.M. Morphia $1/10$ $MgSO_4$, 2cc. 25%, no pain till next A.M. 17
5th. 10.15 A.M. Morphia $1/10$ $MgSO_4$, 3cc., 25%, quiet all day... 10
8.15 P.M. $MgSO_4$ 3cc., very good night..... 19
6th. 3.50 P.M. $MgSO_4$ 3cc., 25%, severe pain after 3 hours 3
6.15 P.M. Morphia $1/8$ $MgSO_4$ 2cc., 25% jerking of leg in 2 hours 2
9.15 P.M. Morphia $1/8$ $MgSO_4$ 2cc., 25% quiet night..... 19
The patient required one hypodermic of morphia $1/10$ to $1/6$ and $MgSO_4$ 2cc. 25% each day after this until December 13th. Codeine and morphia alone did not give relief.

In the paper already referred to, it was stated that "Magnesium sulphate (from 6 to 15 cc.) given by hypodermic injection two hours before operation, followed by morphine sulfate hypodermatically (from $1/12$ to $3/8$ grain) one hour before the operation, when supplemented by nitrous oxide and oxygen (the oxygen being employed in a much higher percentage than usual) gives a safer and better relaxation than when ether is used."

While the magnesium sulfate synergizes with the morphine, prolonging its action, it *deepens the action of the nitrous oxide*, thus permitting the maintenance of a satisfactory narcosis without the use of ether. We now use 30 to 50 cc. of a 25 per cent. solution of magnesium sulfate; this is diluted with sterile water, q. s., 300 to 500 cc., and given as a hypodermoclysis—starting two hours before and finishing one and a half hours before the time for operation. The morphine is given in $1/8$ -grain doses, hypodermatically, at twenty to thirty minutes intervals—the first dose being given one and a half hours before the operation. Three-eighths of a grain is the usual amount. If an idiosyncrasy is present, it reveals itself before the time for the third dose, the patient being thus safeguarded from an overdose.

Where great relaxation is not required, $1/8$ -grain of morphine in 1 to 2 cc. of magnesium sulfate, repeated twice, and supplemented by nitrous oxide and oxygen, is sufficient for a satisfactory narcosis, *i. e.*, the patient is perfectly quiet and is pink at all times.

We started with the supposition that it was best for the patient to be conscious, if possible, during an operation and that robbing him of consciousness was in itself somewhat of a shock. The patients themselves, however, have compelled us to reverse this opinion. The majority of them prefer to be unconscious during an operation of grave import. On this point Keen⁴ states: "The ideal anæsthetic will not be one which will abolish pain without abolishing consciousness. To have the patient aware of surgical emergencies which test even a veteran operator's skill and resources to the utmost would frequently invite death by the terror which it might occasion. The ideal anæsthetic will abolish pain by the abolishment of consciousness, but without danger to life."

Whether conscious or unconscious, however, the patient is better protected from pain impulses by the use of some local analgesic with all anæsthetics, since neither morphine, magnesium sulfate nor nitrous oxide and oxygen, ether nor chloroform seem to have any effect upon the cutaneous nerves, except when administered to the point of saturation.

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Cushny² holds that "The peripheral muscles and nerves are unaffected by morphine in any except overwhelming doses." The following cases indicate both the amount and the time, as well as the effects, of the synergistic method.

CASE I.—*Carcinoma of rectum*.—Sacral approach—removal of lower part of sacrum and coccyx.

Male, age sixty-one (48230), large, heavy, chronic aortitis and chronic bronchitis.

6.30—10 cc. $MgSO_4$ 25 per cent. subcutaneously.

7.00— $MgSO_4$ 1.5 cc. Morphia gr. $\frac{1}{8}$; Chloretone supp. gr. x.

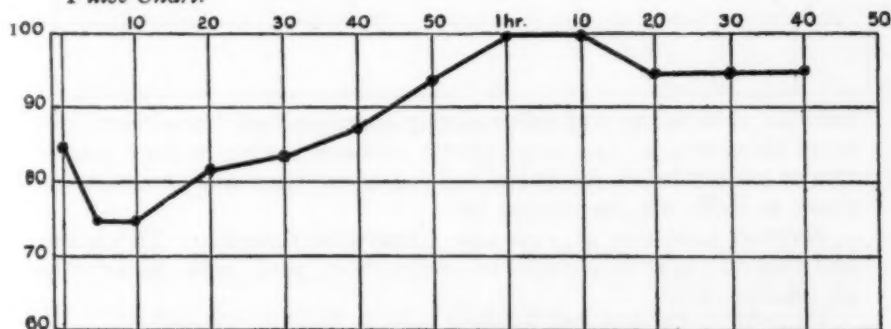
7.30— $MgSO_4$ 1.5 cc. Morphia gr. $\frac{1}{8}$; Chloretone supp. gr. x.

8.00— $MgSO_4$ 1.5 cc. Morphia gr. $\frac{1}{8}$.

Operation 8.50 to 10.20.

N_2O and O_2 administered.

Pulse Chart:



6 Hours post-operative Pulse 96 }

Respiration 16 }

10 Hours post-operative Pulse 90 }

Respiration 20 }

Remarks: Patient had wonderfully good effects from above medication. Relaxation good. Breathing as in natural sleep. Amount of gas decreased, and oxygen increased. Pulse good and full throughout. Respiration normal. No nausea. No vomiting. No sedative until next day, 12.45 P.M.

CASE II.—*Carcinoma of rectum*.—*Excision of rectum and colostomy*.

Female, age forty-three (48384); small anæmic woman, poor surgical risk, apprehensive before operation.

7.30 A.M. 12 cc. 25 per cent. $MgSO_4$ subcutaneously.

8.30 A.M. Morphia gr. $\frac{1}{8}$, Chloretone suppository, gr. x.

8.50 A.M. Morphia gr. $\frac{1}{8}$

9.10 A.M. Morphia gr. $\frac{1}{8}$

Operation 9.47 to 11.28

8 Hours post-operative Pulse 108 }

Respiration 12 }

12 Hours post-operative Pulse 122 }

Respiration 24 }

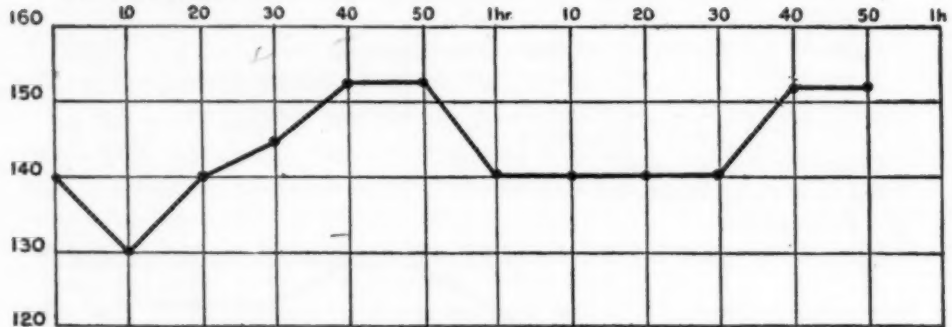
Pulse before operation 140.

Pulse during operation 140 to 152.

Pulse after operation 130 to 152.

Remarks: Respirations were 8 before abdomen was opened; kept up to 16 during abdominal work, but fell to 6 during closure of wound. Respirations again stirred up by perineal work, and fell again at end of operation. Respirations 10 when leaving operating room. Excellent analgesic effect. Perfect relaxation. No nausea. No vomiting.

Pulse Chart:



Infusion 1200 cc. normal saline during operation and transfusion, 500 cc. of blood at 3.30, as a prophylactic measure, owing to poor condition of patient before operation and the severe operative procedure. 8.00 P.M. Pulse 108; respiration 12.

Sedative next day at 2.30 P.M. Uneventful recovery. This is the first and only case of slowing of respiration and was apparently an idiosyncrasy.

CASE III.—Incarcerated inguinal hernia—intestinal obstruction.

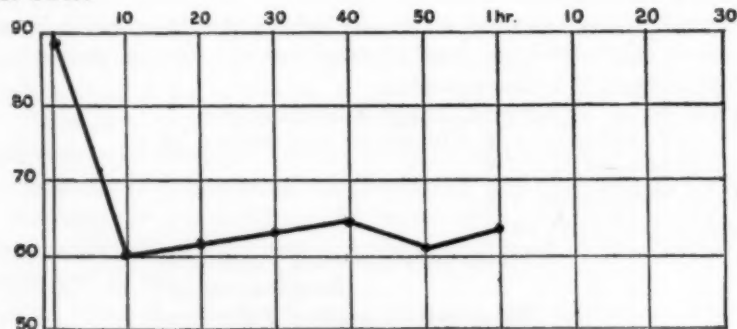
Male, age forty-nine (48129) average build, vomiting before operation.

11.20 P.M. $MgSO_4$ 4 cc. 25% morphine gr. 1/6 by hypodermic.

11.35 P.M. $MgSO_4$ 4 cc. 25% morphine gr. 1/6 by hypodermic.

Operation 11.50 to 12.45. Anæsthesia: gas and oxygen. Good relaxation, no ether required. Slight nausea, vomited 60 cc. brownish fluid. Slept all night—medication required morphia gr. 1/5 the next night.

Pulse Chart



8 Hours post-operative Pulse 68 }
Respiration 28 }

12 Hours post-operative Pulse 64 }
Respiration 24 }

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CASE IV.—*Acute appendicitis.*

Male, age eighteen (48189) nephritis and acute rhinitis.

11.35 P.M. 2 cc. MgSO_4 25% morphia $\frac{1}{12}$ by hypodermic

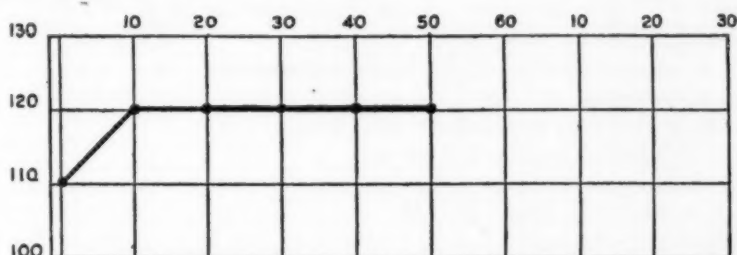
11.50 A.M. 2 cc. MgSO_4 25% morphia $\frac{1}{12}$ luminal gr. 1 by mouth.

12.05 P.M. 2 cc. MgSO_4 25% morphia $\frac{1}{12}$.

Operation 12.25 to 1.34

Novocain—later— $\text{N}_2\text{O} + \text{O}_2$.

Pulse Chart:



7 Hours post-operative Pulse 124 }

Respiration 30 }

11 Hours post-operative Pulse 120 }

Respiration 24 }

Remarks: Anaesthesia, novocain and nitrous oxide and oxygen. Skin incision made without anaesthetic. Novocain necessary in lower muscle layers. Continuous pain after getting into peritoneum. Gas-oxygen given, very good relaxation with low per cent. of gas. No nausea. No vomiting. Sedative 1.45 A.M. next night.

In each of the above cases the surgeon stated that the relaxation was very much better than in similar cases when no magnesium sulfate was used and was comparable to the relaxation under full ether anaesthesia.

The next few cases illustrate the use of MgSO_4 and morphine alone, with local analgesia for the skin.

CASE V.—*Direct Hernia.*

Male, age thirty-three (48343); strong robust young man.

7.40 A.M. MgSO_4 25 per cent. 25 cc. subcutaneously.

8.00 A.M. Morphia gr. $\frac{1}{8}$.

8.20 A.M. Morphia gr. $\frac{1}{8}$.

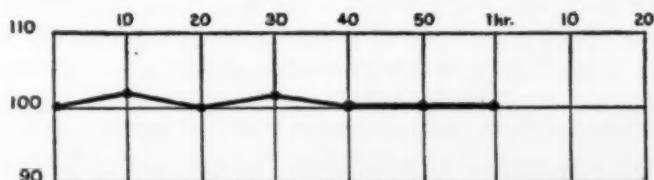
8.30 A.M. Chloretone suppository, gr. xv.

8.40 A.M. Morphia gr. $\frac{1}{8}$.

9.00 A.M. Morphia gr. $\frac{1}{8}$.

Operation 8.36 to 10.36.

Pulse Chart:



GWATHMEY AND GREENOUGH

6 Hours post-operative Pulse 84 }
 Respiration 24 }
 10 Hours post-operative Pulse 84 }
 Respiration 28 }

Remarks: Patient complained of no pain during operation. Slight burning noticed twice during closure. Facial expression remained placid. Skin suture felt like pin-prick. Novocain used in skin. No nausea or vomiting. No sedative at any time.

CASE VI.—*Hernia, direct.* Male, age sixty-four (48907), average size and build; tuberculosis of lung.

8.30 A.M. 30 cc. 25 per cent. $MgSO_4$ subcutaneously.

8.45 A.M. Morphia, gr. 1/8.

9.00 A.M. Chloretone suppository, grs. xv.

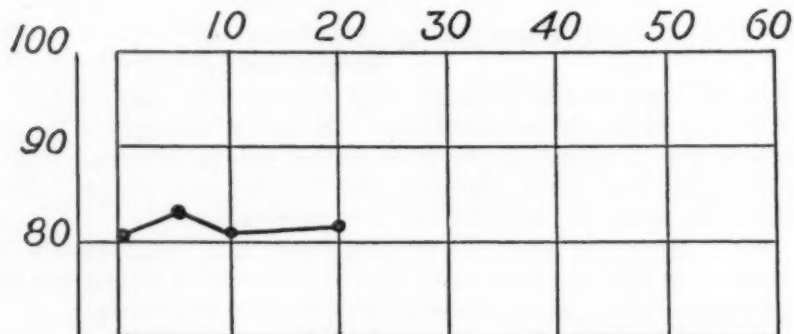
Cannabis indica, p.o. gr. 1.

9.15 A.M. Morphia hypo gr. 1/8.

10.30 A.M. Morphia, hypo, gr. 1/8.

Operation 10.35 to 11.08.

Novocain used.



6 Hours post-operative Pulse 72 }
 Respiration 20 }
 10 Hours post-operative Pulse 78 }
 Respiration 22 }

Remarks: Small amount of novocain infiltration for skin and neck of hernial sac. Duration, 33 minutes. Remaining procedure painless. Complete relaxation. No nausea. No vomiting. No post-operative sedative. Pulse 80 at start, rose to 84, and dropped to 72. Pulse 72, respiration 18, on arriving at ward.

In not a single instance was there any laxative effect from the magnesium sulphate, and the absence of gas pains was most noticeable. The absence of nausea and vomiting in nearly all these cases and the length of time after the operation before a sedative was required, seem to prove: (1) That nausea and vomiting are reduced as far as it is possible to do so by the anæsthetic agents; and (2) that the amount of morphine or sedative in any given case is also reduced to a minimum. In other words "wound pain" almost invariably

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is a thing of the past, the patients being carried through the pain zone easily and comfortably, without any further administration of morphine.

The two following tables, compiled from the charts of the Presbyterian Hospital, would seem to prove this contention.

PATIENTS RECEIVING 25% MgSO ₄ (5 TO 30 C. C.)			
No.	Operation	Sex	Time of post-operative sedative
1	Direct hernia.....	Male.....	None
2	Double inguinal hernia.....	Male.....	32 hours
3	Carcinoma of rectum.....	Male.....	29 hours
4	Carcinoma of rectum.....	Female.....	28 hours
5	Acute appendicitis-gen. peritonitis.....	Female.....	30 hours
6	Incarcerated hernia.....	Male.....	24 hours
7	Chronic appendicitis.....	Female.....	17 hours
8	Acute appendicitis.....	Male.....	13 hours
9	Carcinoma of stomach.....	Male.....	13 hours
10	Ischiorectal abscess.....	Female.....	12 hours
11	Chronic appendicitis.....	Male.....	12 hours
12	Chronic appendicitis.....	Male.....	12 hours
13	Chronic appendicitis.....	Female.....	10 hours
14	Chronic appendicitis.....	Male.....	5 hours
15	Inguinal hernia.....	Male.....	4 hours
16	Lacerated wound of leg.....	Female.....	3 hours
Total elapsed time.....			244 hours
Average time.....			16 hours, 16 minutes

PARALLEL SERIES OF CASES WITHOUT THE SYNERGISTS

No.	Operation	Sex	Time of administration of sedative
1	Ischio-rectal abscess.....		None
2	Carcinoma of rectum.....		None
3	Hernia.....		15 hours
4	Incarcerated hernia.....		10 hours
5	Chronic appendicitis.....		3 hours
6	Acute appendicitis.....		2 hours
7	Chronic appendicitis.....		6 hours and 12 hours
8	Double hernia.....		3½ hours and 12 hours
9	Left inguinal hernia.....		3 hours and 10 hours
10	Chronic appendicitis.....		2 hours and 14 hours
11	Carcinoma of rectum.....		2 hours and 9 hours
12	Chronic appendicitis.....		1¼ hours and 8 hours
13	Carcinoma of stomach.....		1 hour and 18 hours
14	Acute appendicitis.....		½ hour, 2, 6 and 12 hours
Total elapsed time.....			49¼ hours
Average time.....			4 hours, 6 minutes

The average time after an operation for the administration of a sedative is 16¼ hours with the synergists and 4 hours 6 minutes without this aid. The patient is comfortable four times as long with the synergists as without them, and receives less morphine.

With the synergists, the appetite is better on account of the absence of wound pain and absence of gas. The normal appetite and absence of gas pain means a marked shortening of the convalescence as well as a much more agreeable one.

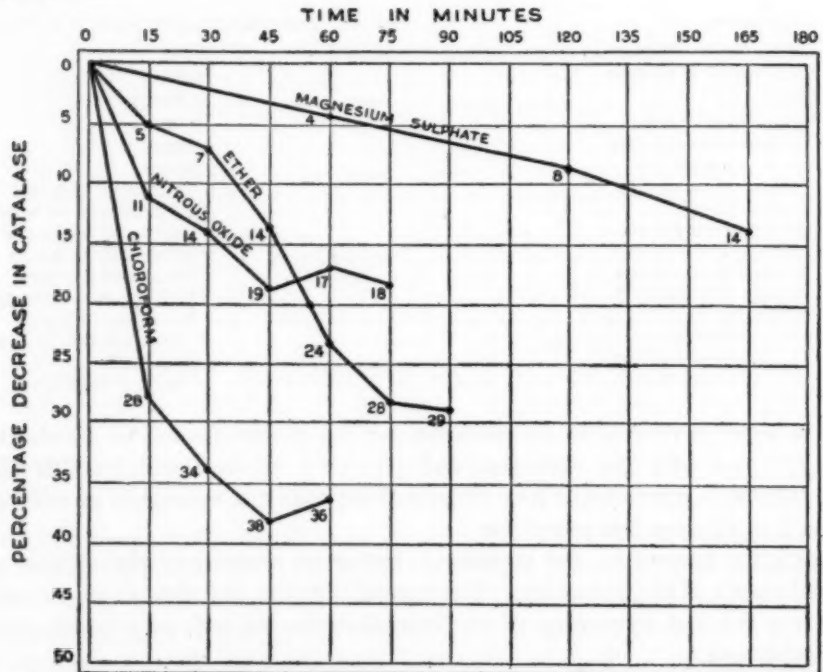
Without the synergists, there were 10 cases requiring supplementary sedatives—not including the first sedative—one of the cases having three

repetitions. With the synergists, there were no repetitions within twenty-four hours after the administration of the first sedative.

One of us (J. G.) assisted or operated in the large majority of the cases and can fully substantiate the statement of Lambert that relaxation with nitrous oxide, oxygen, and the synergists is just as good as without nitrous oxide, oxygen, and ether.

It may be possible, that with improved technique the total amount of morphine used in any given case may be still further reduced. The fact that post-operative nausea and vomiting, and wound and gas pain are practically eliminated, is most important. In the light of our present experience, these dreaded sequelæ of the anæsthetic and the operation can be entirely averted.

Further illustrating the value of magnesium sulfate, compared with other anæsthetics, W. E. Burge⁵, working in the Physiological Laboratory of the University of Illinois, to determine how anæsthetics decrease oxidation, found that "Narcotics of widely different constitution, such as chloroform, ether, nitrous oxide, and magnesium sulfate, decrease the catalase of the blood parallel with the increase in the depth of narcosis. A very powerful anæsthetic, such as chloroform, decreases the catalase more quickly and more extensively than does a less powerful anæsthetic, such as ether. Slowly acting anæsthetics, such as magnesium sulphate, decrease accordingly the catalase of the blood more slowly than a quickly acting anæsthetic, such as nitrous oxide."



While synergistic analgesia—the analgesia obtained by the reciprocal augmentation of the action of drugs upon each other—is still but slightly

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understood, yet the sum total of the results is so overwhelmingly in its favor, as compared with any method of inhalation anæsthesia, that we have no hesitation in submitting these data at the present time.

SUMMARY

1. Morphine and magnesium sulfate synergistically used give good relaxation when supplemented with (a) Nitrous oxide and oxygen to abolish consciousness and for its added analgesic effect; (b) Or by using a local analgesic for the skin and peritoneum.
2. Nausea and vomiting, wound and gas pain are reduced to a minimum and quite often entirely eliminated.
3. When morphine is given as a preliminary to any inhalation anæsthetic, its good effects are observed in the induction, almost entirely abolishing the stage of excitement. The nausea and vomiting occur as the patient is emerging from the inhalation anæsthesia. By using magnesium sulfate with the morphine, the good effects secured in induction are retained; the nausea and vomiting are eliminated, a stage of analgesia being substituted.
4. Morphine and magnesium sulfate give relief from pain either immediately post-operative or at other times for a much longer period than morphia alone.

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CERTAIN FUNDAMENTAL LAWS UNDERLYING THE SURGICAL USE OF THE BONE GRAFT

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No subject has been discussed more extensively in our recent surgical congresses and clinics than the various uses of the bone graft. The theories advanced as a result of laboratory researches have been many. The amount of literature which has been written on the subject of pseudoarthrosis has been voluminous. Unfortunately, however, for the true solution of this problem, the conclusions offered in many of these discussions and reported experimental findings have been immature, or based upon false premises, or upon meagre inadequate observations, and the information presented consequently misleading. This has been due, no doubt in part, to the exigencies of the times and to the necessity in our military services of calling upon the assistance of men never heretofore interested in this work, or those frequently, alas, unqualified by experience or by mental training and adaptability to do justice to these serious problems. As the necessity of the proper observance of fundamental biological, physiological and mechanical laws is more strikingly illustrated in the application of the graft to pseudoarthrosis than any other, the discussion in this paper will largely centre around this subject, although it will apply equally in the use of the graft for any purpose whatsoever.

In the entire realm of surgery there is today no subject of more intense interest to the profession, nor of greater importance to the patient himself, than a consideration of the proper treatment of pseudoarthrosis, with or without loss of bone. The treatment of this stubborn condition centers almost exclusively about the employment of the bone graft. The great numbers of such unfortunate cases resulting from traumata of the recent war have emphasized the seriousness of the situation. In France alone, the author was recently informed, there are over 20,000 cases of pseudoarthrosis awaiting operation. All of which originated in the great war. No estimate has been attempted in the United States, but undoubtedly the number in this country is very great, especially if ununited fractures of the hip are included.

Among the great variety of methods which have been tried in the past in the correction and treatment of pseudoarthrosis have been included numerous experimental attempts to stimulate bone growth, such as the injection into the site of the lesion of blood taken from another part of the patient's body, the Bier hyperemia, deep massage to promote healthy circulation, or the internal administration of medicaments. Triple calcium phosphate has been used by the author locally in early cases with success (see Albee, *ANNALS OF SURGERY*, January, 1920). In cases of pseudoarthrosis of the tibia or femur, various modes of bracing the lower extremity

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have been tried, with the purpose of allowing weight-bearing and function to exert a special stimulus to bone proliferation.

Operative measures have also been attempted in the treatment of this condition; such as plastic procedures on the bone fragments themselves, consisting of "step-up" operations, in which the freshly cut bone of the fragment ends were brought together. In other plastic work, the fractured fragments have been brought into closer apposition, with extensive removal of bone at operation with its consequent unnecessary shortening, for the purpose of contacting the more active bone-growing tissues; this was done in accordance with the theory that the etiological factor in pseudoarthrosis might be traced to some local inability to grow bone in the ends of the fragments.

The introduction of foreign substances, such as metal plates, wires, nails, etc., has been also made in an attempt at correction, frequently in conjunction with operative procedures such as the foregoing. The disadvantages of using metal to hold ununited bone fragments in place cannot be emphasized too strongly; as an additional fixation agent to the bone graft is *absolutely contraindicated*. For some years it has been an established fact that metal, when inserted into healthy, well-nourished bone will cause absorption of the bone it comes in contact with; if it is a destroyer of healthy bone tissues, how much greater must be its destructive influence when it is brought into contact with the free bone graft before and during the period of the establishment of its blood supply! The metal plate is distinctly contraindicated as a supplemental fixation agent to the graft. When used in this way it exerts the destructive influence of a foreign body on local bone cells. It interferes with internal primary union and causes an exudate in the region of or about the graft, thus seriously interfering with the local circulation and consequently impairing the nourishment to the graft and the bone ends. Also, by its introduction the graft is robbed of that most valuable stimulus to normal metabolism and bone growth which is afforded by the graft bearing mechanical stress. The importance of this very influence upon detached blocks of bone cells or unimpaired skeletal bones cannot be too strongly emphasized. In extreme cases of infantile paralysis the diminution of mechanical stress will in part cause the bone cortex to become one-fourth its normal thickness; it will cause all the diameters of a skeletal bone, otherwise unimpaired, to become less than normal. The same phenomenon is true also in ununited fractures with loss of bone, etc. On the other hand, the presence of mechanical stress will cause an almost proportional increase in the diameters of a Sandow's bone, or it will cause a graft of any length of only one-third of an inch or less in diameter to grow back the full diameter of an adult femur.

The inadequacy of such methods as the foregoing in the treatment of pseudoarthrosis is indicated by their very number and variety. During the past twelve years, the author has closely studied many cases in which one or more of these forms of treatment had been carried out. As a result of his observations, it is his firm conviction that all such non-operative procedures,

and particularly those involving the introduction of metal, have no place in a consideration of the *proper* treatment of pseudoarthrosis. The bone-graft operation is the *only* method offering a solution of this problem, and the *inlay* type of technic is the most trustworthy one. These conclusions are based not only upon data resulting from extensive animal experimentations, but more particularly upon a series of more than two thousand bone-graft operations personally performed on the human subject.

In pseudoarthrosis, we have loss of osteogenetic activity at the ends of

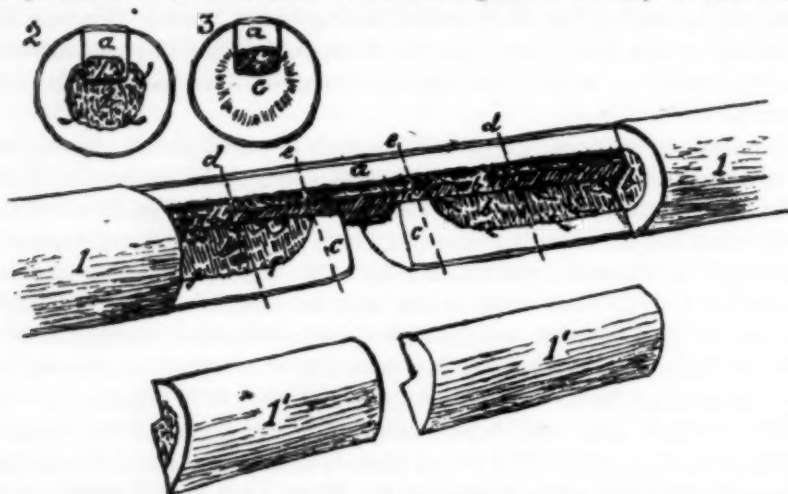


FIG. 1.—Diagrammatic drawing to illustrate the requisite apposition of bone-layers of graft with corresponding parts of host-bone, in the bone-graft treatment of pseudoarthrosis, in this case with loss of bone. These proper relationships of graft-layers with host-layers can be satisfactorily secured only when the graft is inserted by the *inlay technic*.

In this illustration, *a* is the inlay graft inserted in the host-fragments, indicated by *1*. Portions of the host-fragments, indicated by *1'*, have been schematically removed for the purpose of disclosing the interior structures and relationships.

It is necessary, as shown in this drawing, that the graft be of sufficient length to extend well beyond the eburnated area of the host-fragment ends (indicated by *c*) so that it may come in generous contact with the healthy vascular host-marrow, indicated by *b'*.

This relationship is further illustrated in *2*, a cross-section made at *d*, which shows the inlay graft, *a*, in place, with its marrow, *b'*, in generous contact with the host-marrow, *b*. A second cross-section, *3*, has been made at *e*, through the eburnated ends of the host-fragments, indicated at *c*. This demonstrates the inlay graft, *a* with its marrow *b'*, in place in the gutter in the eburnated ends of the host-bone, which has been made sufficiently deep to receive the graft. The marrow, as shown in *3*, not only serves as an osteogenetic force, but on account of its continuity from one host-fragment to the other, it forms an important vascular and osteogenetic conducting bridge. The arrows in *1* and *2* indicate the direction of blood supply from the host-marrow, *b*, to graft-marrow, *b'*.

The cross sections, *2* and *3*, show also the cabinet-maker fit of the inlay graft, *a*, with the host. This not only affords mechanical fixation of parts, but also favors the stimulation to bone growth from frictional irritation (emphasized by Roux) and an early establishment of blood supply for the graft.

the bone fragments, and a failure of the new bone if it occurs (in many cases callus to excess appears around the bone ends) to bridge across and unite the fragments. Frequently in these cases there is also definite loss of bone substance. The object of the inlay bone-graft treatment of this condition is to supply the osteogenetic deficiency in the bone-ends by transplanting in from elsewhere new and active bone-growing cells in such manner that the blood supply will be sufficiently early established and adequate to their continued life and proliferation, at the same time that the graft furnishes the necessary fixation of the fragments.

Many former methods failed to secure this desired result. The secret of

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the success of the inlay bone graft, following nature's laws of biology, physiology and metabolism, is based upon the transplantation of *healthy active bone-cells* to replace those which have lost their osteogenetic activity. As is clearly shown by Fig. 1, the inlay bone graft affords a vascular bridge of marrow substance and periosteum as well as active bone-growing cells, extending from the healthy bone tissues of one fragment to those of the other.

The fundamental principles of bone growth and metabolism, upon which is based the technic of the inlay bone graft, must always be borne in mind. The importance of the observance of these laws can, perhaps, be best emphasized by a consideration of some of the conditions most necessary to the successful employment of the bone graft in the treatment of this extremely difficult surgical problem.

The graft should always if possible be *autogenous*, and either a sliding *inlay* graft from one of the fragments, or taken from the tibia or some other source.

It must be the *internal fixation agent* as well as the *active osteogenetic element*.

It must receive early and adequate supply of blood not only for its favorable growth but for its *very cellular existence*.

Since its blood supply must come principally from the marrow substance, which is the main normal source of blood supply in bone, the graft should contain marrow as one of its definite component parts.

In order that the fundamental laws pertaining to tissue transplantation be fulfilled, the graft must, in fact, consist of *all the four bone-layers*, namely, periosteum, compact bone (cortex), endosteum and marrow. The tissue-layers must be brought into apposition with the corresponding layers of the host-bone, in as nearly perfect apposition as possible.

The graft should be so placed that its marrow substance may serve both as a vascular and as an osteogenetic bridge extending from the marrow of one host-fragment to the marrow of the other. In other words, it must lie in generous, extensive contact with the un-traumatized marrow substance of the host-fragments on either side of the hiatus at the point of non-union. The graft must fit with a cabinet-maker exactness, thereby favoring the early establishment of blood supply, and allowing, to the maximum degree, the operation of Roux's law of frictional irritation (microscopic in amount).

If due regard is to be paid to the biological and to the mechanical principles involved in the use of the bone graft in the treatment of pseudoarthrosis, it is obvious that the *large inlay graft* is the only type which may be successfully employed to secure fixation of the fractured fragments, or to restore extensive bone loss. This type of graft, which by motor-saw technic may be easily cut and removed so as to contain all four bone-layers, is not only capable of serving as the *sole internal fixation agent* for the fractured fragments, but is a *potential grower of new bone*, depending upon its early establishment of sufficient blood supply from the host-tissues.

Despite the difficult requirements in the surgical treatment of pseudoarthrosis, the author realizes that other types of graft, such as the osteo-

periosteal, the pedicled and the intramedullary, have, from time to time, been advocated and used with a certain degree of success in these difficult conditions, a large proportion, however, of the cases, in which these methods have been successfully used were gunshot (military) origin, in which true pseudoarthrosis did not exist. The osteo-periosteal graft is wholly inadequate not only for purposes of fixation, but as a satisfactory osteogenetic factor in the proliferation of new bone in cases of pseudoarthrosis. Its only possible use should be as a supplement to the main inlay fixation graft. The author, however, *never* employs this graft for any purpose, believing that a bone

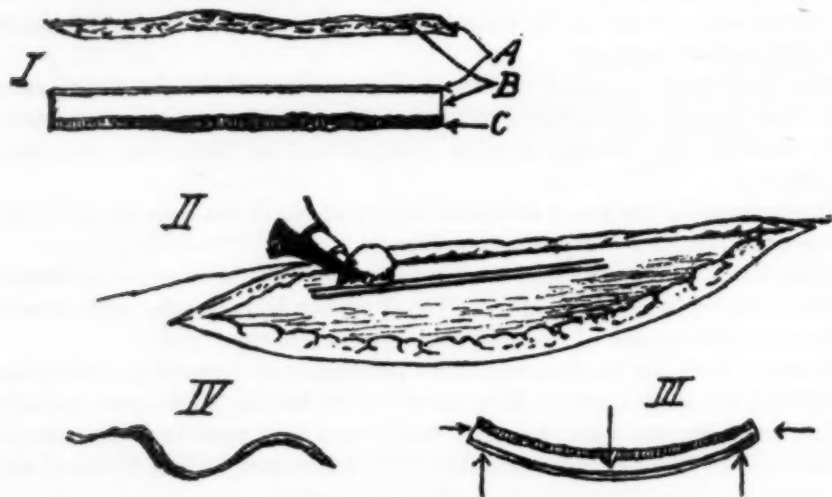


FIG. 2.—In these diagrammatic drawings, Figs. I, II, III, and IV illustrate the fundamental differences in structure and in mechanics between the osteo-periosteal graft, as usually removed by chisel or osteotome, and the author's "silver-graft," removed by means of the motor saw, as shown in II.

In Fig. I, the upper drawing demonstrates the osteo-periosteal graft with its ribbon of periosteum, A, to which are attached plaques of bone cortex, B. As is evident from this diagram, this graft does not possess the mechanical continuity of a rigid structure; moreover, it entirely lacks endosteum and marrow.

In striking contrast to the osteo-periosteal graft is shown the author's "silver graft," the lower figure in I. This graft is composed of *all four bone-layers*, namely, periosteum, A, compact bone, B, and endosteum and marrow, C. It is a complete bone-unit. Furthermore, it is a rigid structure, without solution of its continuity at any point, and it is thus capable of bearing mechanical stress, and is constantly under that powerful stimulus to bone growth. The arrows in Fig. III indicate the direction of the mechanical forces which may be brought to bear upon this graft, bending it in a microscopic or in a macroscopic degree. This illustrates the underlying etiological factor in the stimulus to bone growth afforded by mechanical stress. The impossibility of applying this principle to the osteo-periosteal graft is well demonstrated in Fig. IV.

graft, even when used supplementally, should consist of *all four bone-layers* to be the ideal producer of new bone. For years, however, it has been the contention of the author that the *efficient bone-grower* was not one individual bone layer, nor another, but the *complete physiological bone-unit*, consisting of all four elemental layers, each fulfilling its particular and necessary rôle and correlating with the others in the process of metabolism and bone proliferation.

The osteo-periosteal graft, as usually obtained by means of chisel or osteotome, consists of a strip of periosteum to which are attached more or less isolated chips of hard bone.

Because of the source of this type of graft, it is inevitable that endosteum

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and marrow substance should be lacking, and, therefore, it is not a *complete osteogenetic unit*, nor a mechanical factor since it has no rigid continuity. Such a graft is thus not only unreliable as a bone-growing entity, but, owing to its inability to resist mechanical stress, it is incapable of responding to this most potent stimulus to bone growth.

It has been unfortunate that the osteo-periosteal graft has been used so extensively in the attempted treatment of pseudoarthrosis, especially in the repair of fractures of the lower jaw, with extensive bone loss. In such cases this type of graft has been entirely inadequate to secure fixation of the jaw fragments, or to afford the proper moulding of the contours of the face. Moreover, its lack of sufficient osteogenetic elements, particularly the blood-carrying marrow, does not favor the ultimate establishment of blood supply. Owing to its unadvisable use, failures have resulted, and certain members of the profession have swung to the employment of an awkward and mechanically inadequate substitute, namely the *pedicle graft*, taken from one of the jaw fragments. The pedicle graft has been "a snare and a delusion" in the cases of both fascial and bone grafts, in that it rarely fulfils its one and only object, namely, the transmission of blood to the graft. Either by traumatization of the pedicle, or by its twisting, the blood-vessels do not remain patent, and the only reason for employing a difficult and many times a destructive technic is nullified. It is, moreover, apparent that in any appreciable loss of bone it is impossible to obtain a pedicle graft of sufficient length to provide requisite fixation or satisfactory cosmetic results. Another obvious disadvantage to its technic is that it involves in its removal extensive dissection of the muscles of the neck, just below the jaw. The only justifiable use of the pedicle graft is in selected cases of jaw fracture in which there is little or no loss of bone.

The contraindications to the independent use of the osteoperiosteal graft, or the pedicle graft, are especially emphasized in pseudoarthrosis of the inferior maxilla with extensive loss of bone. This branch of bone repair presents great difficulties of mechanical fitting and adjustment. Although electrically driven instruments in all branches of plastic bone work are necessary, in surgery of the lower jaw they are absolutely indispensable. Owing to the irregularity of contour of the jaw fragments, hardness of the bone, as well as lack of anvil stability, this work demands a precision and an accuracy of technic which can be obtained only by the employment of delicately adjusted motor-driven tools, such as the Albee circular saws, burrs, drills, end-mills and the like. The cosmetic result is of primary importance in these cases, depending in many instances entirely upon the construction of a *suitable graft-frame-work* over which to mould and restore the contours of the face. It is only by means of a *strong graft* moulded for this purpose and firmly *inlaid* into each jaw fragment that the restoration of the proper facial contours can be accomplished.

At a recent congress of the French Orthopædic Association, held at Paris, the author heard a French surgeon make the statement that he had never

in all his experience seen one successful result from the use of the osteoperiosteal graft in true pseudoarthrosis. Such a statement is hardly surprising, for a large percentage of successful results cannot be expected from the use of this graft when we consider the salient features in its technic.

1. Owing to its lack of rigid continuity the osteoperiosteal graft is incapable of furnishing fixation, even to the slightest degree.

2. By nature of its removal it cannot be a complete osteogenetic unit.

3. Since it does not possess rigid continuity, and is therefore incapable of bearing mechanical stress, its metabolism and bone growth are not influenced by that powerful stimulus of withstanding mechanical stress without fracturing.

In place of the osteoperiosteal graft, which the author formerly employed supplemental to the fixation graft, he now employs the so-called "sliver-graft." This is obtained by the motor-saw (see Fig. 2) in the same manner as the large inlay graft, namely, by cutting through the full thickness of the cortex into the marrow substance. In this case, the "sliver-graft" is obtained by single saw-cuts; it is about 1 mm. in width, and may be of any length, although usually of 6 cm. As shown in Fig. 2, this "sliver-graft" is composed of all four bone-layers, and, although of small dimensions, it is actually a *complete bone-unit*. It is so placed that it spans the hiatus between the host-fragments, with its two ends engaging upon the fragment ends at a point where the periosteum has been turned back. It is so thin that it bends and takes the contour of the bones with which it is in contact; as soon as it becomes united to the bone, on either side of the non-union, it is subject to end-bearing or lateral stress at the slightest movement of one bony fragment upon the other, or from contraction of the muscles lying alongside. Since it possesses mechanical continuity, in marked contrast to the osteoperiosteal graft, it is constantly under the influence of the stimulus exerted by withstanding mechanical stress without breaking. The greatest value of this graft is in its use as a supplement to the main fixation graft, for the purpose of furnishing additional foci of bone growth.

In concluding a recent report of a large and varied series of cases of pseudoarthrosis following gunshot injuries, treated by bone graft in his military work, the author urged the scrupulous observance of certain essential points in treatment and technic to which he attributes, in large measure, his successful results in this difficult work. A brief résumé of these requirements seems not inappropriate as a summary of this discussion.

1. *Time to Operate*.—A careful study of the wound should be made, before it has healed if possible. The type of infecting organism (*streptococcus hemolyticus*, gas bacillus, etc.), the nature of the "clean-up" operation, and the manner of healing of the wound should be noted. These observations have a direct bearing on determining the time when it will be safe to operate.

In a few cases it may be permissible to operate after the wound has been completely healed for a period of two months, while in others, on account of possible latent infection where the previous infection has been streptococcus

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hemolyticus, etc., it may be advisable to delay the final plastic work for at least six months. In some of the latter unfavorable cases a two-step operative method may be followed, consisting of a preliminary excision of scar tissue with its replacement by a healthy skin-flap, muscle, fat, etc., followed after a period of from ten days to two weeks by the bone plastic procedure.

2. *Immediate Pre-operative Observation of Patient.*—In order to ascertain whether or not latent infection capable of recrudescence exists, splints should be removed, and rough manipulation and deep massage should be given for a period of from one to two weeks before operation. During this time observation of the temperature should be made, and likewise careful examination of the parts for local tenderness or any evidence of recrudescence of infection. The field of operation should be given a forty-eight hour preparation by the tincture of iodine technic.

3. *Plan of Operation and Choice of Incision.*—By radiographic and physical examinations, the proposed plan of operation, particularly with reference to location of graft, should be made before actual incision. If it is possible, the skin incision should not be located directly over the intended bed of the graft. The operation must be so planned that the graft may be covered without undue tension of skin, and, if possible, placed so that it may come in contact with healthy tissue instead of scar. In a number of cases in which this was accomplished, the graft healed by primary union; whereas the scar, even at a considerable distance from the graft, broke down entirely. In cases in which there is extensive loss of bone, the scar tissue should be pushed to one side, in order that the graft may come in contact with healthy tissue. Drainage wicks, of any kind, must never be inserted at the time of the operation.

4. *Length of Operation.*—The author believes that the shortest possible operating time that is consistent with good work, and with minimum amount of trauma, is requisite to successful results in this work.

5. *Use of Motor-Driven Tools.*—These are essential for the following reasons:

(a.) On account of the necessity for rapid work in order to avoid drying and traumatization of both the graft-tissues and the host-tissues.

(b.) To secure a cabinet-maker fit of parts, thereby providing for early and adequate blood supply to the graft, for mechanical fixation and for the operation of Roux's law of frictional irritation which is a great stimulus to bone growth.

(c.) On account of taking advantage of the law of anoci-association.

The motor outfit with its tools to secure automatic fits seems indispensable in this work. The motor-saw when properly used does not heat nor glaze the bone. This has been shown repeatedly by the author in experimentations made formerly and repeated during the past few months.

6. *Adequate Length of Graft.*—The bone graft should always, if possible,

be of the inlay type, and of sufficient length to extend into each fragment for a distance of at least 5 cm., and always well beyond the eburnated area at the ends of the fragments. The gutter should extend well into the healthy marrow of the host-bone, with which the graft-marrow should be in generous contact. It is important that the marrow in the fragment ends should not be crushed or unduly traumatized, and that the gutter in it should be of proper depth to just receive the graft, so that there will be a close approximation of the marrow of graft to the marrow of the host-fragments, thus favoring the early and profuse anastomosis of blood-vessels between these very vascular tissues. It is also important that a marrow-bridge be formed from the marrow substance of one host-fragment to that of the other for the transmission of blood-vessels, bone-cells, etc., across the point of non-union.

7. *Type of Graft.*—The graft should be autogenous, consisting of *all four bone-layers*, namely, periosteum, complete thickness of cortex, endosteum and marrow. It should be so inlaid that the fit is perfect, with an exact apposition of layers of the graft to the corresponding layers of the host-bone. This exact contacting fit favors the mechanical fixation of the fractured bone and the graft; it also permits the frictional stimulus to bone growth, emphasized by Roux, and in every way favors the earliest bony union of graft to host-fragments.

8. *Supplemental Grafts for Additional Foci of Bone Growth.*—Small "sliver-grafts" about 1 mm. in thickness placed alongside of the main fixation graft furnish additional foci of bone growth. They are most efficacious when used in this manner.

9. *The Graft as the Main Fixation Agent.*—Fixation should be secured always by the graft itself, and never by metal plates or other foreign material, for the metabolism of the graft and bone growth are directly influenced by the stimulation from the stress carried by the graft.

10. *Suture Material.*—A minimum amount of absorbable suture material should hold the graft in place. For this purpose kangaroo tendon is the most ideal material, since it is tolerant to the tissues, readily absorbable, very strong and reliable. For the skin and the underlying soft parts fine absorbable suture material should be used.

11. *Post-Operative Fixation.*—Firm immobilization of the limb by a plaster-of-Paris cast should be maintained for a period of at least ten weeks following operation, and as long thereafter as radiograph examination shows it to be required. Great emphasis should be placed upon the importance of very efficient immediate post-operative fixation, and this can be accomplished only by the most expert management of a suitable fracture orthopaedic table (such as the Albee fracture table) which will allow control of both the upper and lower extremity and skillful plaster-of-Paris technic.

The author is convinced that failures in cases of pseudoarthrosis operated by others, where the bone graft was used, were due many times more to inadequate post-operative fixation than to poor operative technic. This statement is especially true in cases with or without loss of bone substance in the upper

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two-thirds of the humerus, where it is absolutely necessary to immobilize both the elbow and the shoulder joints by a plaster-of-Paris shoulder spica, and it was for this type of cases more than for any other that the author was induced to devise his fracture orthopædic table.

Adequate fixation of the graft, following its insertion, is equally essential in the same work in the vegetable kingdom.

Grafting wax is more necessary for this purpose than it is in protecting the cut surfaces from vegetable parasites. It is for this reason that when the wax does not remain hard and becomes unduly soft under the sun's rays, successful results are interfered with.

Attention is again drawn to the importance of using absorbable skin suture material, in order that the plaster dressing need not be disturbed until time for the splint to be removed.

RESULTS OF TREATMENT OF 115 CASES OF FRACTURE OF THE SHAFT OF THE FEMUR AT THE UNIVERSITY OF PENNSYLVANIA HOSPITAL

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THE statistical facts in this article are based on a series of the last 115 fractures of the femoral shaft, occurring in the various surgical services at the University of Pennsylvania Hospital, Philadelphia. There has been no attempt to compare any one man's work with another, but to find the method of treatment that gave the best result. In the last four years our ideas about the treatment of fractures of the shaft of long bones, especially of the femur, have undergone some striking changes. Some years ago our treatment for all fractures of the shaft, not including the neck, was either a double inclined plane, a fracture box, or a plaster casing from the toes to the costal margin, with the limb usually in the mid-position, *i. e.* in the long axis of the body with no flexion at hip or knee. In some instances, traction and lateral support in the flat position constituted the dressing.

The results did not appear sufficiently satisfactory, and so the open reduction and internal fixation was tried in increasing numbers of cases. Again, most operators applied plaster casing with the limb in practically the straight position, *i. e.*, laying flat on the bed. Still the results did not satisfy. Later two or three of the surgeons began to practice the principle of flexion of the thigh and leg and traction in all cases, including those with internal fixation by wire, bands or plates. To render the nursing of these patients easier they were fastened to a modified Bradford frame¹. Use was made of the Hodgen splint with traction in certain selected cases and more recently the Thomas splint was also used. All of the methods have been employed in the present series, and in some cases two or more of the methods have been used in an attempt to accomplish position.

The series is composed of 115 cases of fractures of the shaft of the femur. No cases of fracture of the neck, non-union of the shaft, or shaft fractures associated with other serious trauma which resulted in early death are included.

Age.—The youngest patient was eleven months old. The oldest treated primarily for the fracture was seventy-six. The decades with the greatest number were the first two. There were twenty-nine cases under ten years of age and twenty-seven cases of the series were in patients within the ten to twenty year age group. That is, 48.7 per cent. of the cases were patients under twenty-one years of age. The next largest group of 17 per cent. occurred in the third decade between twenty and thirty, and the smallest group of 2.6 per cent. occurred in patients between forty and fifty years of age. The other periods are of no interest.

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Character of Injury.—This was not obtained in all of the series. Direct violence was the causative factor in 73 per cent. of the cases and indirect violence the cause of 27 per cent. Of those due to direct violence an automobile was the cause of 42 per cent.

Type of Fracture.—The fracture line was described as transverse in 56 per cent. of the cases, oblique in 16 per cent., comminuted in 20 per cent., compound comminuted in 9 per cent., and unstated in 9 per cent.

Level of the Fracture.—For convenience of classification the fractures have been grouped into those of the upper third, the middle third and the lower third of the shaft. The lower third includes supracondylar fractures but not condylar fractures where there is no lesion of the shaft proper. In the series, 20.1 per cent. of the fractures occurred in the upper third, only two cases of which had comminution. The middle third of the shaft claims 56.4 per cent. of the series with five comminution cases included. The lower third accounts for 24.5 per cent. An interesting feature of this group is that comminution occurred in 40 per cent. of them, as compared to only 8 per cent. of comminution cases in each of the other groups. Included among the fractures in the lower third are but two cases of epiphyseal separation, one compound with torn popliteal vessels which resulted in loss of the leg. The other gave a happy result under operative reduction.

Deformity.—In all the cases with the exception of two, there was shortening ranging from 1 cm. to 6.5 cm. The upper fragment invariably was flexed and lay anterior while the lower fragment presented posteriorly. The upper fragment in the upper and middle third fractures was abducted. Three of the cases had fractures of both femora.

Treatment.—Throughout the entire series it has been the policy of the various surgeons in charge of the cases to be conservative and accomplish reduction if possible by the closed method.

With this in view in every case, after the diagnosis, some attempt at reduction was made by manipulation and traction, and the limb dressed either with sand bags, a posterior splint, or an inclined plane, each with a temporary Buck's extension and weights ranging from 6 to 40 pounds, depending upon the musculature of the patient. An X-ray was then taken and treatment directed accordingly. In only seven cases was any anæsthetic other than morphia given for reduction. This was satisfactorily accomplished in but one of the entire series of eighty-eight, later proven by the X-ray. This one, with a cast applied in the flat position, was found again out of position when X-rayed two days later.

Thus we are faced with the astonishing fact that the results of the primary treatments were unsatisfactory in 100 per cent. of the cases. It is fair to state, however, that in the great proportion of the cases but little, and that usually by the resident interns, or no attempt was made at reduction but merely a fixation and traction applied while waiting for the X-ray. If the X-ray revealed that the site and type of fracture so demanded, the limb was

dressed with traction and in splint, plaster or box in the flexed position, *i. e.*, thigh flexed on abdomen and leg on the thigh.

Character of Dressing.—For infants and young children the type of dressing most frequently used was the Buck's traction, with either one or both legs directed toward the ceiling. The writer has obtained the best results when both limbs were suspended. Enough weight was applied to just lift the buttocks so that they would swing easily, just touching the mattress. Rotation of the broken limb was prevented by parallel riders attached to the foot piece and projecting to straddle the rope on the uninjured side. In only one case, the oldest in the series so treated, a child of eight years, was a Steinmann nail traction necessitated.

The youngest case so treated was eleven months of age. There were twenty-four of these cases, up to age eight, of which fourteen were treated by this perpendicular traction, twelve of the fourteen, 84.1 per cent. were reported on as having good results, three were operated and seven were put in plaster cast, and all were discharged as having no deformity. Of the two remaining one had a cm. shortening and the other was reported merely as "overlapping." The three operated cases had good results. The seven cases treated with plaster casts showed no shortening in four (57 per cent.), and with ultimate good results. We, therefore, may say that in this group our best treatment is clearly pointed out, namely, the perpendicular traction (Bryant). The results for this entire group of twenty-four cases can be considered good.

The remainder of the series, eighty-eight in number, really constituted the problem. An attempt was made in two or three of the cases of ten or eleven years of age, to dress with the perpendicular traction, but without success. The adhesive would not carry the weight of the limb in the perpendicular position.

In eighty of the series of eighty-eight over ten years of age, in which the primary type of dressing was mentioned, the adhesive extension (Buck's), or better termed traction, with weights was used. Of the remaining eight cases, some were operated at once because of the nature of the injury, and others were etherized and placed at once in a plaster casing in the flat position, *i. e.*, with the limb lying straight out and flat on the bed.

Following the eighty-eight fractures through, eight were later encased in plaster, including the pelvis and foot; of these six had shortening, ranging from one-half inch to $2\frac{1}{2}$ inches, one fibrous union, and one died, so we may state that the treatment gave satisfaction in none of the cases. In twenty of the cases failure caused a change of dressing to be made. The thigh and knee were flexed to about 45 to 60 per cent. and supported with a Hodgen splint, an angled Thomas splint or a double inclined plane fracture box and traction in the line of the femur's long axis. This is the position of greatest ease and relaxation of the muscles that exert action on the femoral shaft. In every case of the series the upper fragment was flexed and when the lesion was in the upper two-thirds, slightly abducted, while the lower fragment was invariably rotated posterior. This was true even in the two cases

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of epiphysial separation, despite the fact that the lower fragment as a whole was displaced anteriorly in these two cases alone. In those cases in which the reduction was not maintained by reason of loosened screws or broken plates there was always the return to the old deformity, in those cases dressed flat without regard to muscle action. When, however, by flexion and abduction the muscles were placed in a state of "equilibration" and traction added this deformity did not return, but shortening persisted in eight cases, due to insufficient traction. Thus, this, the second attempted treatment, gave good results with no deformity in 25 per cent. in this group of twelve cases.

This was the final treatment in twelve of the twenty cases of which three recovered with no shortening, two of which were direct bone pin extension cases, one resulted in amputation because of vessel injury at the time of the accident, and eight had a resultant shortening ranging from one-half to three-quarters inches and one with $1\frac{1}{2}$ -inch shortening was too sick from a head injury for any radical treatment of the fracture. This last case had both femurs broken and a resulting $1\frac{1}{2}$ -inch shortening in both limbs—hence no limp.

In eight of these twenty cases dressed in the flexed position satisfactory reduction was not obtained and open operation was done. In six cases perfect results were obtained, one a case of compound comminuted fracture involving the knee-joint died of septicæmia, and one case in which no traction was used had a resulting $\frac{3}{4}$ -inch shortening and angulation.

In forty-six cases, after the first reduction and fixation in the "flat on the bed" position did not produce results, and in the eight fractures, unsuccessfully dressed in the flexed position, operation was decided upon. The Sherman plates with four or six screws were used in forty-seven cases, wire in three, Parham-Martin bands in two, and no internal fixation in two. After operation twelve were dressed in the flexed position, *i. e.*, leg and thigh flexed to 45 per cent. and thirty-four were dressed in the flat position. Plaster casings were used in all fifty-four cases and postoperative traction was applied in ten, of which six were bone pin and three adhesive traction and one was by traction screws incorporated in segmented plaster casings. The majority of the open operations were performed within the first eight days. Comparatively few were done within the first twenty-four hours. It was universally noticed that the earlier the operation the easier the reduction.

The results were grouped for study and analysis into those of early occurrence, such as infection, permanency of the internal bone fixation and union, and secondly the ultimate results such as the amount of lasting disability, etc.

Infection.—Infection occurred in six, 15 per cent., of the operative wounds of the total of fifty-four operated cases out of the entire 115. This occurred in the earlier cases of the series, and necessitated the removal of the plate in three of the cases. The type of the infection in these cases in which a culture was taken, was found to be a staphylococcus. Fourteen of the wounds were drained with a rubber tube for forty-eight hours. In none of these was there

any infection. It was, however, noted that the majority of the operative cases ran a more prolonged and a higher temperature than should be expected.

No one of the retarded union or non-union cases occurred in these fourteen drained cases. It is possible that draining the hæmatoma, which must to a more or less extent occur in such an operative wound, allows the tissues to fall together and the stripped-up periosteum to cover the bone more closely, consequently encouraging reparation. Of these same fourteen cases, however, twelve were dressed in the flexed or muscle equilibrium position with post-operative traction.

Bone traction by the Steinmann pin was used in only six cases in all. These all had an infection develop peculiarly at the entrance site of the pin. In only one case did the infection reach the bone, in which case an acute epiphysitis occurred necessitating the removal of the pin and the establishing of drainage some three weeks later. This patient, a child of eight, has been followed up and an X-ray taken recently, four years since the operation, shows a healthy bone and a perfect result at the fracture site. Tongs were used in two cases, neither of which resulted in infection.

Paralysis.—In three cases, a peroneal palsy developed with its associated toe drop. This in one case was due to a tight cast just below the head of the fibula and in two cases to the cinch used around the upper part of the leg in obtaining traction at the time of operation. All three cases recovered within seven weeks.

Duration of Plate, Wire and Band Stability.—Plates were used in forty-seven of the cases. The screws became loose, resulting in angulation in ten clean cases and in three infected cases. The plate broke in three cases allowing angulation in two and overlapping in the other case. It became necessary to remove the plates in ten cases, seven clean and three infected, and the bands in one case.

It is interesting to note here that in only two of the sixteen cases in which the plates failed was there traction applied after plating. In one of these two the limb was put up in the flat position and in the other there was infection. In the three cases in which wire was used one resulted in 1-inch shortening and the other two developed angulation. In none of the wired cases was traction used after operation. In the two cases in which bands were used, one resulted in subsequent angulation and shortening necessitating a second operation, and the other cannot be traced.

From the above we must notice that in the twenty-one cases, 44.7 per cent., in which the internal fixation failed of its purpose, only two occurred in the presence of postoperative traction, and these two were explained the one by infection and the other by faulty equilibration of the muscles. Only one of the twenty-one cases occurred with the limb in the flexed position and that was in the absence of traction.

Union.—It may be well to state here that the state of union was determined by X-ray and physical examination at the time of discharge from the

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hospital. In the entire series of 115 cases there were fifteen ununited, as follows: one each after 49, 60, 67, 84, 87, 180, 240, 55, 93, 143, 126, 70 and 74 days after operation. The remaining two cases have no record of the number of days. In answer to inquiry letters three of these cases have subsequently obtained union; the others could not be traced.

When examined in groups we find fourteen of the poor union cases were operative and one was non-operative; of the operative cases three were infected, five were comminuted and one was a case in which no internal fixation was used. The non-operative case was a man of seventy years of age.

Here again the flexed position has a clean slate with no delays or non-union to its credit. All the non-union cases had been dressed in plaster and flat on the bed. None of the operative non-union ones were drained. Only one had postoperative traction applied and in none did the fixation remain firm. Relative to the site of the fracture, nine were in the middle third, four in the lower third, and two in the upper third of the shaft. Age of the patient had no apparent bearing on the absence of union.

Six of these cases were sent home in their casing at periods ranging from eighteen to forty-eight days and told to report on a certain date, at which time angulation and non-union was found, or angulation sufficient to be reported as vicious union.

Deformity.—The presence of deformity was determined by the amount of shortening or the demonstration of angulation by X-ray at the time of leaving the hospital. It is only fair to state that a great number of the cases with angulation, ten of a total of thirty-six, pass clinically as good results though the X-ray shows a deviation from the straight axis, yet they still remain as examples of failure of fixation.

Of the eighty-eight cases there were thirty-six with no deformity, either shortening or angulation by X-ray. There were thirty-six with deformity. The remaining sixteen were made up of two cases of amputation, two deaths and twelve undetermined.

Of the thirty-six cases with deformity, twenty were operative cases, ten of which, having only X-ray deformity of slight angulation and no shortening or other clinical evidence of deformity, cannot be so considered, but three showed shortening and seven showed deformity angulation. The angulation cases with one exception had been dressed in the flat position.

For all practical purposes, viewed clinically, functionally and aesthetically, the incidence of deformity in the fifty-four operative cases was ten, or 18.4 per cent. The ratio of deformity in non-operative cases was sixteen in the thirty-four, or 44 per cent. Of these sixteen cases, thirteen were a loss of length and three were angulation, pronounced enough to be noticeable.

This shows that operation resulted in shortening in three cases and bad angulation in seven, in all 18.4 per cent., whereas non-operative procedures resulted in thirteen cases of shortening and three of angulation, 44 per cent. deformity. All angulation cases necessarily show some shortening.

In the series of eighty-eight, 18.8 per cent. of the cases showed shortening and 11.3 per cent. showed angulation, a total of 30.1 per cent.

We therefore find that by the operative treatment, we obtained 81.6 per cent. good results, and by the non-operative methods we obtained in the entire series 73.9 per cent. good results, but only 56 per cent. good results in the series limited to ten years and over.

Carrying the analysis of the operative good results further we find that the flexion and traction postoperative treatment was given in ten cases with plaster casings for external fixation. The results were nine cases with no angulation or shortening and one case with $\frac{1}{4}$ -inch shortening, *i. e.*, 90 per cent. good results, practically 100 per cent., as such a small shortening is negligible.

Of the thirty operated cases dressed in the flat on the bed position and in plaster with no traction, twenty resulted in deformity, usually angulation, *i. e.* 33 1-3 per cent good results.

The remaining fourteen operative cases were divided between Hodgen splint two, Thomas splint two, posterior splint and plaster two, and others not described definitely enough to report.

Days in Hospital.—Of the seventy-five adult cases the hospital term has been taken in forty-eight, twenty-eight operative and twenty non-operative cases. The average stay in days for the operative cases was eighty-three days, and for the unoperated cases sixty-three days.

Mortality.—There were three deaths in the 115 cases. One was a result of embolus, one a compound comminuted case died of septicæmia, and another compound with lacerations died from gas gangrene.

Morbidity or Permanent Disability.—The number of reports obtainable is not very satisfactory. Only forty cases show reports after leaving the hospital.

In addition to the twelve cases of delayed or non-union, nineteen cases have no complaint or disability, two suffered amputation, two have a stiff knee, one wears a high shoe, one wears a brace, one uses crutches, one is convalescing from a second operation for vicious angulation, and one case has a relaxed knee joint resulting in a "back knee." This patient was plated, put in plaster casing in the flat position, and a fenestra cut over the wound for removal of drainage tube. As did occur in three cases of this series and in five other cases brought to the writer's attention from other sources under similar treatment, *i. e.*, with lack of traction and muscle equilibration and the presence of a fenestra, the screws pulled and angulation occurred projecting into the fenestra.

The effort to correct this by traction on the leg resulted in the relaxed knee joint. This is a point to be borne in mind in choosing between adhesive or direct bone traction, exerted on the broken bone itself rather than with a joint intervening.

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SUMMARY

1. In patients under eight years of age the Bryant or perpendicular treatment gave the best figures, 85 per cent. excellent, or 100 per cent. good results. In this group all results were reported as good.

2. In the eighty-eight cases ten years of age or older the primary reduction and dressing was not satisfactory in a single case.

3. A small group of eight cases later set in plaster under traction, all showed shortening or non-union.

4. The next group of twenty cases dressed in the flexed position with weight traction gave 25 per cent. good results with no deformity.

5. In operative cases infection occurred in none of the drained wounds. Every case however showed slight infection around the Steinmann nail.

6. Internal fixation failed to hold the fracture in twenty-one of fifty-four cases. Causes of this failure were in the greater number of cases due to the position in which the limb was splinted, twenty being dressed in the flat position, and to a much less extent to infection, only three cases.

7. Non-union, or better, union delayed longer than seven weeks, was most often due to faulty fixation of the fracture, and occurred in 22.2 per cent. of the operative, 0.86 per cent. of the non-operative and 10+ per cent. of the entire series. It is hardly fair to include these figures as other than undetermined, as they have not been heard from finally.

8. Operation gave 81.6 per cent. good results; non-operative methods gave 73.9 per cent. good results in the entire series of 115. It must be remembered, however, that this last figure is helped enormously by including the twenty-four youngsters with 100 per cent. good results.

9. Of the operative procedures, the use of plates and screws with wound drainage and the limb dressed in plaster, in flexed position, with postoperative traction maintained, gave 90 per cent. perfect results, plus 10 per cent. good. All other operative methods gave but 33 1-3 per cent. perfect results plus 33 1-3 per cent. good results.

Plaster casings are not a good permanent dressing unless traction is used and the case kept under close observation until union is firm and especial care being taken as shrinkage of the limb occurs, a new cast be applied. This last is very important, for if there is too much room in the cast at the fracture site, each time the patients raise themselves in bed the psoas muscle acting against the fracture will loosen the internal fixation. If these precautions are taken, however, plaster makes an excellent dressing if cut out so as to permit knee and ankle motion.

10. From the above facts we see that the best treatment was operation with plate fixation and drainage and the same amount of attention given to external fixation, flexed position and traction as would be given were the case treated by the closed or non-operative method.

¹ Eliason: Method of External Fixation for Fractured Femur. Surg., Gyn. and Obst., Oct., 1918.

FRACTURE OF THE METATARSAL BONES*

WITH A REPORT OF FOUR CASES

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FOUR cases of fracture of the metatarsal bones have come under my care at the Episcopal Hospital within the past few months. In three of these cases the results of treatment have been very satisfactory. The fourth has been too recent to determine the final outcome, although so far he has progressed most satisfactorily and I believe he will also get a useful foot.

Apparently very little attention has been given to fractures of the metatarsal bones, as I have been able to find only a few articles in the literature, and the text-books dispose of the subject in very few words.

All of the text-books which I have consulted written prior to Robert Jones'¹ articles in 1902, when he described a fracture occurring in his own fifth metatarsal as the result of indirect force, describe the fracture as usually being due to a direct or crushing force. Since Jones' article, the more recent text-books still adhere to the direct or crushing force as being the most likely causative factor, but make mention of Jones' article or say that it is possible for the metatarsal bones, especially the fifth, to be broken by indirect force.

Certainly fractures of the metatarsal bones have been considered quite rare, as Agnew² states that during a period of forty-four years twenty-six cases were admitted to the Pennsylvania Hospital, and that only three or four cases were treated at the Hôtel Dieu, Paris, during a period of eleven years. From 1905 to 1920 one hundred and four cases of metatarsal fractures have been admitted to the Episcopal Hospital, fifteen of these were compound.

Wharton³ reported two cases of fracture of the metatarsal bones as the result of a twist of the foot, the so-called soldier's fracture, and Tabold has reported over 700 cases observed in soldiers, almost all caused by indirect violence as in marching, jumping, etc. In Tabold's⁴ series, the second metatarsal was most frequently broken, then the third.

My cases were all due to direct foot injuries, but it was hard from the histories, except in Case I, to really understand the mechanism or to properly follow the line of force producing them.

In one case (Case I) transmitted or indirect force certainly played a part in breaking some of the bones.

The symptoms in all of the cases were quite marked and consisted of inability to bear the weight on the foot, swelling which came on very rapidly and was quite marked, ecchymosis, deformity, crepitus and mobility in some and marked localized tenderness in all.

In dealing with multiple fractures such as occurred in each of these, it was

* Read before the Philadelphia Academy of Surgery, April 4, 1921.

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impossible clinically to always tell the number of bones broken, the exact location of the fractures or the amount of displacement of the fragments.

In Case III, where there was not so much deformity or swelling, we were able to make a probable diagnosis of a fracture by the exquisite localized tenderness to pressure although no crepitus or mobility was obtained.

The first case on whom I operated, I did so with much hesitancy and fear. My war experience had taught me that there was nothing to be feared more than a compound fracture of the tarsal or metatarsal bones, and I feared if I operated and the wound became infected the case might terminate most disastrously. My experience, however, with these cases has shown that with good hospital facilities infection is not apt to occur, or is it after all that the foot not only was made to stand on but will stand a lot besides?

A brief history of the cases is as follows:

CASE I.—A. C., white, male, aged twenty-six years, fireman, admitted May 10, 1920, discharged June 1, 1920. Diagnosis: Fracture of the shafts of the second, third, and fourth metatarsal bones, dislocation of the third, fourth and fifth metatarso-phalangeal articulations. On May 10, 1920, while sliding at great speed down a brass pole in the station house, the outer side of his right foot struck the floor with great force, causing his foot to turn under him. On admission to the hospital the right foot showed swelling and discoloration, more marked on the outer dorsal surface, crepitus and mobility and great tenderness over the second, third and fourth metatarsal bones and evident dislocation of the fifth metatarso-phalangeal articulation. *X-ray Report*: "shows fracture of the shafts of the second, third and fourth metatarsal bones." "There is angulation of the fragments of the second and the heads of the third and fourth are dislocated completely outwards." "There is a complete dislocation of the proximal phalanges of the fourth and fifth toes." "The proximal fragment of the third metatarsal projects sharply towards the dorsum of the foot."

On May 11, 1920, under ether anaesthesia, an attempt was made to reduce the fractures and dislocations without success. On May 17, 1920, the patient was operated upon under ether anaesthesia. Elliptical incision with convexity towards the toes was made on the dorsum of the foot over the metatarsal bones. The heads of the second, third, fourth and fifth metatarsal bones at the phalangeal articulation exposed and the fifth reduced, being dislocated. The fractures of the distal extremity of the second, third and fourth metatarsals then reduced and held in position with chromic catgut sutures. Wound closed without drainage.

The patient made an uneventful recovery except for a small area of slough of the skin flap.

CASE II.—J. M., white, male, aged twenty-eight years, fireman. Admitted June 7, 1920, with a compound fracture of the shafts of the second, third, fourth and fifth metatarsal bones, right. Fracture dislocation of the bases of the first, second and third metatarsals, right. On June 7, 1920, while responding to a fire call the fire en-

gine on which the patient was riding was struck by a locomotive, and in the crash which followed his foot was crushed against the railroad track.

On admission to the hospital his right foot and ankle were greatly swollen, with marked deformity, crepitus and mobility of all the metatarsal bones. The entire foot was exquisitely tender. The dorsal surface of the foot was markedly contused and there was a lacerated wound on the plantar surface. *X-ray Report*: "Fracture of all right metatarsal bones." "The fragments of the second, third, fourth and fifth are shoved outwards and are fractured near the distal extremities." The first, second and third are fractured near their proximal ends and the first is dislocated inward on the cuneiform bone.

On June 17, 1920, under ether anaesthesia an unsuccessful attempt was made to reduce the fractures and dislocations. On June 24, 1920, patient operated upon under ether anaesthesia. Four longitudinal incisions made on the dorsum of the foot over the metatarsal bones. Dislocations and fractures of all metatarsal bones. Fractures and dislocations reduced and bones held in position by fine silver wire. Wounds closed without drainage. Recovery uneventful and patient discharged on July 17, 1920.

CASE III.—F. S., white, male, aged thirty-three years, knitter. Admitted November 1, 1920, with compound fracture-dislocation of metatarso-phalangeal articulation of great toe. Fracture shafts of second and third metatarsal bones.

On November 1, 1920, patient fell down an elevator shaft a distance of about twenty feet, landing on his left foot. On admission to the hospital his left foot showed a lacerated wound on the inner side at the base of the great toe. The first phalanx of the great toe is dislocated outwards. There was marked tenderness over the heads of the second and third metatarsal bones. *X-ray Report*: "Fracture of the second and third metatarsal bones near the distal extremity, in fair position." "The distal fragments project somewhat towards the outer side of the foot." "Fracture-dislocation of the proximal phalanx of the great toe."

On November 1, 1920, under nitrous oxide anaesthesia, patient was operated upon. Incision about three inches in length made over the inner surface of the left foot at the base of the great toe. Dislocation of great toe reduced and capsule sutured with chromic gut. Wound closed without drainage. Patient discharged from the hospital on November 8, 1920, wound healed.

CASE IV.—G. B., male, white, aged fifty-eight years, machinist. Admitted January 29, 1921, with compound comminuted fracture of the shafts of the second, third, fourth and fifth metatarsal bones, right; dislocation of little toe, right.

On January 26, 1921, while on a ladder, it slipped from under him and he fell a distance of twenty feet. In falling, his right foot slipped through one of the rungs of the ladder so that in landing the ladder fell on his foot and he in turn on the ladder.

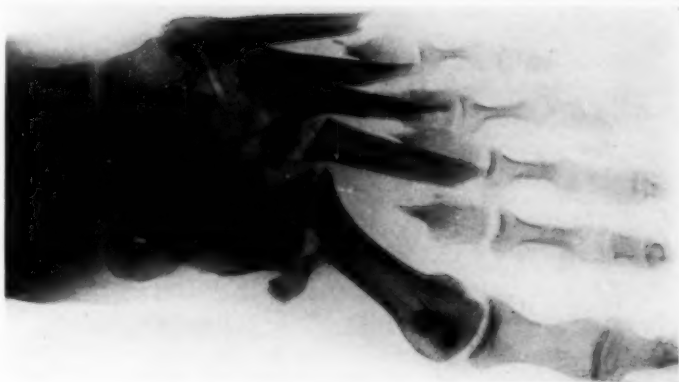
On admission the right foot was greatly swollen and ecchymosed.



CASE I.



Case I. End Result



CASE II.



CASE II. End result.



CASE III.



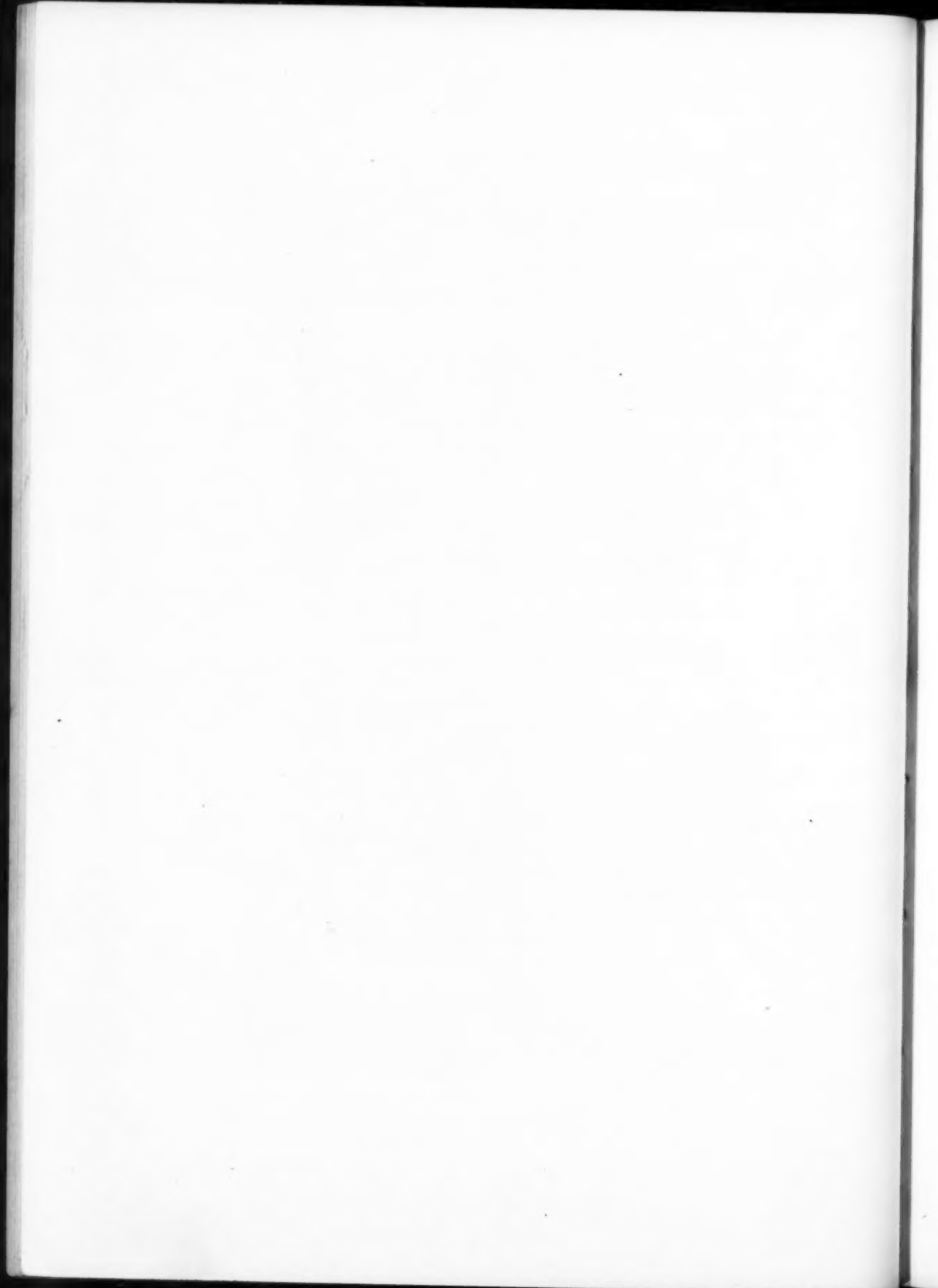
CASE III. End result.



CASE IV.



CASE IV. End result.



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There was a puncture wound on the plantar surface of the foot opposite the second metatarso-phalangeal articulation. Marked localized tenderness, crepitus and mobility obtain over the distal extremities of the second, third and fourth metatarsal bones. *X-ray Report*: "shows a fracture of the second, third, fourth and fifth metatarsal bones, distal extremities." "There is apparently a fracture of the cuboid." "There is also a partial dislocation of the first and fifth metatarso-phalangeal joints." "The displacement of the fourth metatarsal is quite marked."

The patient was operated upon under ether anaesthesia on February 3, 1921. Three incisions about three inches long made over the second, third and fourth metatarsal bones on the dorsal surface of the foot. It was found that the second, third and fourth metatarsal bones were badly comminuted and that the proximal fragments were markedly displaced towards the plantar surface of the foot. The fragments were reduced and an attempt was made to hold them in position by chromic gut sutures, but on account of the smallness and extensive comminution of the distal fragments this was found to be impossible. The head of the fourth metatarsal was so badly comminuted that it was removed. The wound was closed without drainage. Wound healed by first intention and patient discharged on February 22, 1921.

The⁵ tarsal and metatarsal bones are so arranged that they are somewhat dome-shaped, giving an antero-posterior and lateral arching to the foot. The antero-posterior arch has been divided into an inner and outer arch, the former consisting of the os calcis, astragalus, scaphoid, three cuneiform and the inner three metatarsal bones; the latter of the os calcis, cuboid and outer two metatarsals. The lateral arch externally through the base of the fifth metatarsal is in contact with the ground, whereas internally it is not in contact with the ground but gains its support through the ligaments and muscles. The posterior pillar of the antero-posterior arch is made up of the os calcis and astragalus and is quite strong, though comparatively immovable; whereas the anterior pillar of this arch is made up of the heads of the metatarsal bones and is quite movable. This elasticity of the anterior pillar makes it more resistant than the stiff posterior arch against active pressure.

The weight from the body is transmitted from the astragalus to the tuberosity of the os calcis, the heads of the metatarsal bone and to the base of the fifth metatarsal bones. A person falling and landing on his feet is more apt to fracture the os calcis than one of the metatarsals, and if the metatarsals give way the inner ones are more frequently broken than the outer.

The strain of the arch of the foot according to Von Meyer⁶ and others is carried by the second and third metatarsal bones, and this seems to be correct, for according to Tabold's series these two bones were more frequently broken than the others by indirect force, as in marching, jumping, etc.

Lateral deformity in metatarsal fractures has been considered by some not so important as an upward or downward displacement of the fragments, as in the latter boot-pressure may be most annoying. Traumatic flat-foot is

probably the most serious sequela of metatarsal fractures, and this is largely due to a loss of convexity of the metatarsal bones. If it is true that the second and third metatarsals carry the strain of the arch, then a fracture of these bones with a loss of their convexity is almost certain to be followed by static disturbance.

In fractures of the metatarsals, if no marked deformity exists, conservative treatment should be carried out, but if there be deformity sufficient to markedly destroy the convexity of the bones, especially if more than one bone is broken, or the fracture includes the second and third metatarsal bones, then operation should be considered.

Those of us who have done much marching appreciate and know what a blessing it is to have good sound feet, as there is nothing which so quickly disqualifies a person as foot trouble. In all metatarsal fractures we should think of the result, and to obtain a good useful foot it is imperative that the bones be restored as near as possible to their original position.

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CHORIO-EPITHELIOMA FOLLOWING HYDATIFORM DEGENERATION

WITH REMARKS ON THE USE OF RADIUM*

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It is the general belief that chorio-epithelioma and its frequent precursor, hydatiform mole, is of rather rare occurrence. The fallacy of this belief has been so convincingly brought to me during recent months that I have felt a study of this subject might be of interest.

Although when a medical student I saw three cases of hydatiform mole, all followed by malignant chorioma, during a period of fifteen years since, no more cases came under my observation, at least none were so recognized, until in the past eighteen months during which time I have treated four cases of hydatiform mole, while two other cases have occurred in the practice of my colleagues in St. Vincent's Hospital during the same period of time. Four of these six cases were followed by chorio-epithelioma, the other two being operated at an early stage while still benign moles.

The prevalent idea of the infrequency of these conditions is probably due to the text of authors long since out of date. For instance, Edgar in his book states that placental mole occurred four times in 15,000 cases. Williams observed five in 5000, while Madame Boivin states that the condition occurs once in 20,000 conceptions. My own experience of the past eighteen months, coupled with a study of the more recent literature, would at once show the fallacy of the old teachings, and convince the student of today the necessity for greater familiarity with the subject and a more watchful attitude in the care of all conceptions, both tubal and uterine.

Meyer states that in 348 pathological uterine abortions the incidence of hydatiform degeneration occurred in 43 per cent., while in 104 tubal pregnancies classed as pathologic the hydatid mole followed in 46 per cent. Meyer's numerous and recent writings cover most completely all sides of this study and he finally states, "Indeed, how many cases of hydatiform degeneration one can find in tubal and uterine abortions will depend very much upon the care with which the examination is made, for the condition is undoubtedly extremely *common* and not rare, as heretofore supposed."

The foetal placenta is developed from the chorion, and through the chorionic villi is derived the nourishment for the foetal organs. These villi are finger-like projections covered on the surface with the layer of syncytial cells, next beneath the cells of Langhans', and then the stroma containing a small number of capillaries. As the placenta develops the villi show rapid

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growth and great erosive power by which they are able to penetrate through the uterine mucosa into the underlying venous sinuses, where, by selective absorption, they gain nourishment for themselves and for the placenta. When conditions are normal and the foetus about mature, these villi withdraw from their intra-mural position; the outer layer of syncytial cells covering the villi has long since undergone atrophy; the layer beneath Langhans' cells also undergo degeneration and thus the attachment between mother and foetus is loosened in preparation for birth. But this does not always happen, for some of the villi may persist in intimate contact with the maternal tissues and maternal blood and may continue to grow in situ after the normal period of gestation has been attained. Continuing to be nourished by the maternal blood and to absorb fluid, they may hypertrophy and become distended by an oedematous mucoid infiltration so as to form a mass or series of clear, grape-like vesicles of varying size, distending the uterus to even as great an extent as a full term foetus. Such is the hydatiform mole.

When the above condition remains within normal limits the result is nothing more than a benign mole; this is expelled in due time or is surgically removed, and thereby is explained the fairly frequent cases of hydatiform mole which are followed by repeated normal pregnancies. On the other hand the villous growth may proceed beyond the normal limits; the venous sinuses may become filled with an active proliferation of the chorionic elements; the epithelial cells may be swept away by the blood current and deposited in the capillaries of the vagina, pelvic vessels, lungs and other organs, and thus we have a transition from the benign mole to the highly malignant chorio-epithelioma.

I have already referred to the rather common frequency of hydatiform degeneration found in pathological abortions, both tubal and uterine, but of greater importance is the incidence of malignant chorio-epithelioma resulting from the transition of the epithelial elements of the placenta mole. Briquet, in a series of sixty-five hydatid degenerations, found that malignant chorioma followed in thirty-one demonstrable cases. Pollasson and Violet, in the study of 455 cases of chorio-epithelioma, found that mature hydatiform mole or hydatiform degeneration of pathologic abortion occurred as a precursor in 366 instances. To emphasize the importance of careful examination of all placentas it may be added with stress that these same investigators found ninety-seven chorio-epithelioma followed hydatiform degenerations discovered during labor near term.

With the present unrecognized frequency of these conditions it is not surprising to find that the initial symptoms may first appear as the result of metastases in vagina, lungs or brain, producing thereby a vaginal tumor, cough with hæmoptysis or cerebral apoplexy. The lungs seem to be the most common site for metastasis. In the above quoted series of cases metastases occurred in the vagina ninety-three times, in the brain forty times, and in the lungs 133 times. Ewing, in discussing the rapidity with which malignancy follows hydatiform degeneration, states that the transition usually takes

place about five weeks after labor at term, seven weeks after abortions, and about eight weeks after mature mole. In one of my cases (No. 4), well-developed chorio-epithelioma was found in the scrapings removed one week after the mature mole was discharged.

The maternal mortality of simple placental mole is quoted as 13 per cent. by Edgar and 18 per cent. by Dorland. This mortality is usually due to hemorrhage or sepsis, and the rate is entirely too high provided these cases can have hysterectomy performed before molar abortion occurs. After malignant transition occurs the mortality rate is quoted about 100 per cent. by all authorities. Ewing states that with or without hysterectomy the disease permits life for from six to eighteen months, and further states that he has been unable to find any operative cure of chorio-epithelioma. Adami states that the process is rapidly fatal. Schmauch emphasizes the necessarily fatal issue and advises against operation. Since the primary malignant process always develops entirely within the venous sinuses and capillaries, it would seem almost impossible to avoid displacing intra-vascular fragments during hysterectomy and thus hastening metastasis. On the other hand if this susceptible foetal hyperplasia could be stunned or its growth inhibited by radium, there might be a greater possibility of cure following hysterectomy. This agent was employed on three of my patients, with results in two cases that are both promising and encouraging.

My experiences may be related briefly as follows:

CASE I.—A negress with soft symmetrical uterine tumor, carrying a pre-operative diagnosis of fibromyoma, upon whom hysterectomy was done before molar abortion had occurred. This patient is living and well.

CASE II.—White, age forty-six, came under my care three weeks after expulsion of the larger portion of an hydatid mole. Fragments of the mole could be extracted with the examining fingers through the patulous os. The general condition of the patient was wretched; a grave secondary anemia following continuous hemorrhage for three weeks, with rapid, feeble pulse absolutely precluded operative interference. 1800 mhrs. of radium treatment within the uterus was followed in one week by complete relief from metrorrhagia. In eight weeks the patient was greatly improved with a gain of twenty pounds in weight. At this time bleeding from the uterus recurred, but the general condition of the patient was so good that operative interference was undertaken. Again 1800 mhrs. of radium was given as a pre-operative measure within the uterus and forty-eight hours later pan-hysterectomy was performed. The specimen removed showed a well localized, perforating chorio-epithelioma in a state of regression and degeneration. Eighteen months has elapsed since this patient expelled the mole and she is now living and apparently well.

CASE III.—White, age forty-two, presented about the same problem as Case No. II, coming under my care for continuous and depleting uterine hemorrhage following molar abortion five weeks previous.

Fragments of the remaining hydatiform mole removed with placental forceps showed no evidence at that time of malignancy. The same radium dosage was employed and the hemorrhage promptly checked, but returned again in five weeks. Profiting by the experience of Case No. II, I did not wait for better general improvement, but operated forty-eight hours after a second radium application of 1800 mhrs. within the uterus. The specimen removed disclosed a more widespread area of chorio-epithelioma than in Case No. II, but the entire pathological process showed marked destructive and degenerative action from the radium. Eleven months have elapsed since this patient was first treated by radium and she remains well to this date.

CASE IV.—This case is recent. Seven days after expulsion of a huge hydatid mole the scrapings from the uterus showed well-developed chorio-epithelioma and the fact that the accompanying hemorrhage promptly yielded to radium within the uterus. The general condition of this patient is too precarious at this time to permit of radical operative measures.

I have just received data of a case in the practice of one of my colleagues in which a smaller dosage of radium, 400 mhrs., checked the bleeding and apparently relieved the patient of all symptoms following the expulsion of the benign mole four months ago.

CONCLUSION

The frequency of hydatiform degeneration and the ready transition into chorio-epithelioma should counsel every practitioner to be on the alert especially in pathologic abortion, both tubal and uterine. A more extensive experience with radium in these conditions may lend hope in the treatment of the malignant transitions which heretofore have been considered necessarily fatal.

Additional justification for this hope may be found in the recognized susceptibility of embryonal structures to radium, especially if used early, for Ries has reported intact villi in a uterine sinus eighteen years after the last labor and the latency of malignant chorio-epithelioma, one, three, five and even ten years has been established by the literature.

PERFORATED GASTRIC AND DUODENAL ULCER WITHOUT PREVIOUS PAIN

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AND

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RECENTLY, in reviewing our histories of perforated gastric and duodenal ulcer, we found that four of fifteen cases in which our histories were complete, or 26 per cent. of them, were instances where perforation was the first sign of abdominal pathology. This was the incentive for the writing of this paper, since we have not been able to find any paper discussing the subject entirely from this point of view.

It has been the observation of every surgeon of experience in abdominal surgery that there are two types of gastric and duodenal ulcers, the typical and the atypical. It is only the first variety with its hyperacidity, pain associated with regurgitation and vomiting, and a tendency to spastic constipation, that can give a history of importance in the diagnosis of an acute perforation. Errors in the diagnosis of this type, if seen before a diffuse or generalized peritonitis has developed, do not and should not frequently occur. In the atypical variety, however, which may or may not be associated with hyperacidity and which may not be accompanied by pain, it is often impossible to make an exact diagnosis, for the perforation may come on as the first sign of a latent ulcer.

The explanation of the presence or absence of pain in ulcer depends upon a knowledge of the anatomico-physiological reflex of gastric and duodenal pain. It is necessary to know the innervation of the stomach and duodenum in order to understand this reflex. The stomach and duodenum receive their innervation from two separate and distinct systems, that is, the para-sympathetic and the sympathetic systems. These systems together with the sacral para-sympathetics compose the autonomic system. The autonomic motor nerve cells which innervate all involuntary muscles were originally like those nerve cells of the voluntary muscles situated within the central nervous system, and correspond to the anterior horn cells of that system.

The main para-sympathetic nerve is the vagus, which is distributed to the heart and to the alimentary canal and its outgrowths. The vagus connector fibres to the alimentary tract have their terminations in a group of motor cells situated between the circular and longitudinal muscles of the stomach and intestines which are known as Auerbach's plexus. Bayliss and Starling, working along the line suggested by Gaskell, have demonstrated that both the longitudinal and circular muscles contract upon stimulation of the vagus and that neither contract upon stimulation of the sympathetic nerve. Thus we see that the vagus is the dominant factor in both the motor

and secretory innervation of the stomach and duodenum. As Gaskell has pointed out, however, the vagus supplies motor fibres only to those alimentary muscles which are of endodermal origin. It initiates the sensation of hunger and the secretion of gastric juice, it plays an important rôle in gastric and duodenal peristalsis, and it maintains the tone in these viscera.

The sympathetic nerves, on the other hand, have an antagonistic effect on the vagus, in that they are inhibitory to the endodermal musculature, and motor to the dermal musculature of the intestinal tract. There is no evidence that the sympathetic motor fibres reach as high as the œsophagus. The present evidence would lead us to believe that the cardiac incisure of the stomach is the upper limit of sympathetic supply.

To sum up then, we have two antagonistic systems concerned in the region under discussion. The vagus (para-sympathetic or cerebral autonomic) supplies the cardiac sphincter and cardiac end of the stomach with both motor and inhibitory fibres and also motor fibres to the pyloric half of the stomach and to the duodenum. The sympathetic (splanchnic or thoracico-lumbar) supplies the pyloric half of the stomach and the duodenum with inhibitory fibres and the pyloric sphincter with motor fibres. This intricate arrangement gives us our best example of reciprocal innervation and physiological antagonism.

Bayliss and Starling have shown that when any part of the alimentary tract is stimulated to contraction the part below relaxes, and they call this "the law of the intestine." Meltzer termed this the "law of contrary innervation," and applied the term to the entire alimentary canal. Its action is seen normally in the relaxation of the sphincteric orifices when peristaltic waves from above approach them. Elliot, in his "Law on Innervation of Hollow Viscus," said, "When the quiet lodgment of contents is facilitated by the presence of sympathetic inhibitory nerves to the body of the viscus, there will also be sympathetic motor nerves to the sphincter closing the exit." Thus Elliot was the first to show that, whereas in the stomach sympathetic inhibitory impulses are antagonistic to peristalsis, the sphincter will be innervated by motor fibres from the same system.

Up to this point we have spoken of the autonomic system as a complete nervous system, but this is in reality not the case. Langley and Gaskell have shown that all the afferent fibres of the autonomic system have their cells in the posterior root ganglia. The course of the afferent or sensory nerves is therefore the same as in the sensory portion of the spinal nerves of the cerebro-spinal system, and they have no demonstrable connection with the cells in the sympathetic ganglia.

When we consider the cause of ulcer pain we must consider the subject of visceral pain in general. One of the supposed causes of ulcer pain is that ascribed to a hyperacid gastric juice, acting on the exposed nerves in an ulcer base. This theory is not reliable, since we occasionally see patients with typical ulcer pain who at operation have "healed ulcers" and only scar tissue remaining. Einhorn has also pointed out that some patients have

ulcer pain with an associated achylia gastrica. Hurst, in attempting to solve this question, introduced four ounces of a 0.5 per cent. solution of hydrochloric acid into the empty stomachs of each of six patients, in all of whom the diagnosis of gastric ulcer was later confirmed at operation, with no sensation resulting. This same result occurred when a mixture of hydrochloric acid and pepsin was used. It is certain that as much as 0.5 per cent. of free hydrochloric acid is never present in the stomach. This undoubtedly proves that contact with free hydrochloric acid is not the direct cause of pain in gastric and duodenal ulcer.

The relief offered by alkalis suggests that the pain is in some way associated with the presence of free hydrochloric acid. Very few afferent nerve endings are found in the mucosa, the majority terminating in the submucous and muscular coats. Hyperacidity stimulating exposed nerve endings in an ulcer base sets up an excessive reflex motor activity. This was pointed out by Edlemann working in Pavlov's laboratory who found the peristaltic activity proportional to the amount of acid present. In the following explanation of the cause of pain in gastric and duodenal ulcer we are accepting Hurst's theory of tension as being the only adequate stimulus producing visceral pain. It is well known and we have recently demonstrated to ourselves that the gastric mucosa is insensitive to the usual painful stimuli such as pricking, pinching and cutting. This has been observed by any surgeon who has performed a gastrostomy under local anaesthesia. Hurst has shown that Lennander and Mackenzie did not take into consideration that a nerve ending may be sensitive to one form of stimulus—the adequate stimulus—but insensitive to all others. According to Langley the painful sensations of the stomach and small intestines are conveyed by the sympathetic and not by the vagus. On the other hand Miller, in 1911, proved that motor and secretory reflexes which resulted from irritation of the gastric mucous membrane depend on afferent impulses carried by the vagus and not by the sympathetic. It is to be presumed that the afferent nerve-endings are more strongly stimulated when they are exposed in an ulcer base than when the mucous membrane is intact. This is also in accord with our knowledge that a greater number of afferent nerve fibres pass from the deep structures of the gastric wall, which are exposed when there is ulceration of the mucous membrane. These findings correspond to the demonstrations of Head that referred pain and tenderness in gastric and duodenal ulcer is almost always found in the distribution of the seventh, eighth, and ninth dorsal segments, with which segments the afferent sympathetic nerves of the stomach and duodenum have their central connection. Reflex pain through the vagus must be expressed in the distribution of the trigeminal, because of the termination of the afferent vagal fibres in the trigeminal nucleus. Thus pain and the associated symptoms of gastric and duodenal ulcer may be explained on the basis of disturbance of Meltzer's "law of contrary innervation."

The increase in peristalsis associated with hyperchlorhydria and the prolonged inhibition of pyloric relaxation which occurs when the hyperacid

chyme reaches the duodenum can only cause real pain when food is present in the stomach, as no rise in intragastric pressure can occur when there is nothing in the stomach upon which the muscular coat can contract. Assuming that ordinarily in a gastric ulcer the pylorus does not relax as the increased peristaltic waves approach it, we have a gradual increase in intragastric tension as the segment between the peristaltic contraction and the point of obstruction is shortened by the advance of the former. This results in violent pain, the result of tension on the muscular coats produced by an enormous rise in intragastric pressure.

Pain does not frequently result from distention of the entire stomach, but more commonly results from segmental distention. Cannon has shown that the cardiac end of the stomach is a receptacle for holding food and the active churning movements are confined to the pars pylorica. The peristaltic movements begin at the cardiac incisure and deepen as they move toward the pylorus. Just above the pyloric canal they deepen to such a depth that part of the pyloric vestibule becomes almost completely separated from the upper gastric cavity. As the peristaltic wave progresses this cut-off portion diminishes in size, which results in a part of the segmental contents being forced through the pyloric canal and the remainder back into the general gastric cavity. Normally, the internal gastric pressure in the pyloric end of the stomach which is necessary to force chyme through a relaxed pylorus is insufficient to cause sensation. But when due to abdominal pathology the peristaltic waves are more frequent and of greater intensity, they begin nearer to the fundus of the stomach than usual and they also separate the pyloric end of the stomach from the rest of the organ at a point more distant from the pylorus than under normal conditions. This increased peristaltic activity results from the hyperchlorhydria, plus the presence of the ulcerated area. The result is a larger quantity of chyme being compressed as each wave advances. This, together with the inhibition of pyloric relaxation which occurs, as Pavlov has demonstrated, when the hyperacid chyme reaches the duodenum, affords a sufficient rise in intragastric tension to produce pain. This pain increases as the peristalsis becomes more active, and as the pyloric relaxation is inhibited for longer periods by a gradually increasing hyperacid chyme reaching the duodenum.

The time relations for the onset of pain are easily explained if we consider at what moment free hydrochloric acid comes into contact with the ulcerated area so as to lead to an exaggeration of the reflex motor stimuli which produce pain. Hydrochloric acid is secreted chiefly by the glands in the upper two-thirds of the stomach, the extreme pyloric end as Langdon Brown has shown being actually alkaline. Carbohydrate digestion continues for some time in the fundic portion of the stomach, but protein digestion is very slow. This slow protein digestion is not due to a lack of hydrochloric acid, but it is due to the absence of peristalsis which prevents a mixture of the contents in this region. The outer layer of chyme, because of this lack of churning, is therefore quite acid. When an ulcer is present in the cardiac

PAINLESS GASTRIC ULCERS

or fundic region, this hyperacidity sets up hyperistalsis which begins very high in the stomach. This accounts for the nearly instantaneous pain in upper gastric ulcer. Food reaching the pyloric end of the stomach is alkaline, and remains so for a considerable period of time after ingestion. This is due to the active peristalsis in the pyloric portion constantly mixing the food and gastric juice which form chemical combinations with each other. Therefore an hour or more may elapse before there is sufficient free acid to irritate an ulcer near the pylorus.

The pain may begin or be more intense several hours after a meal. Here it is due to an increase in the tone of the stomach as that organ empties itself. This allows the pyloric end of the stomach to be closed off more completely from the upper gastric cavity and the result is increased intragastric tension of the lower segment.

Hurst in a series of cases of duodenal ulcer examined by the X-ray found that the stomach begins to empty itself immediately after the food swallowed reaches it. The stomach, as X-ray observations show, is hypertonic, and the gastric contents are at first extruded with such rapidity as to give to the action the name "duodenal rush." Thus at the time a patient is free of pain after the ingestion of a meal, food is actually passing over the ulcer. Due to the excessive and prolonged secretion of normal gastric juice, causing the so-called hyperchlorhydria of duodenal ulcer, the proportion of gastric juice and hydrochloric acid in the chyme increases as digestion proceeds. At first, as in gastric ulcer, this acidity is neutralized by combination with the alkaline salts and protein in the food, to which are added the alkaline bile and pancreatic juice. This results in only an occasional pyloric inhibition, but after two or three hours the proportion of acid being greater, some of it reaches the ulcer without being neutralized and the inhibition of pyloric relaxation is accentuated. The X-ray examination now shows a small amount of food in the stomach with the gastric hypertonicity at its maximum, having increased as the bulk of gastric contents decreases. Long after the fundus has returned to a fasting condition, the pyloric portion contains food and shows very vigorous peristaltic action. This again brings about the condition where peristaltic contractions can produce a complete separation of the pyloric part from the rest of the stomach at a considerable distance from the pylorus. Thus we may have three favorable factors for the production of pain, hypertonicity, excessive peristalsis, and inhibition of pyloric relaxation, the pain persisting until the stomach is empty.

In both gastric and duodenal ulcer we may, as we have already said, have a true reflex pylorospasm which may cause a delay in the emptying of the stomach and in this manner cause a hyperchlorhydria. In other words pyloric spasm may produce hyperchlorhydria and hyperchlorhydria may produce a reflex inhibition of pyloric relaxation.

When we come to explain those atypical cases with perforation as the first sign of abdominal pathology, we find a group of cases in which, as Eppinger and Hess have stated, gastric hyperacidity does not occur, which are

not accompanied by pain or eructations. Some of these are only found at autopsy. These patients are probably the cases described by C. H. Mayo as individuals with "hypo-sensitive abdomens." In them we find signs of a depression of vagus and sympathetic reflexes, with no hyperchlorhydria, no pyloric disturbance, and therefore no pain. It is well known that different individuals react in varying degrees to the same external stimulus, and there is no reason why this observation should not apply to visceral stimulation. We have in the following cases a raising in the threshold of the conscious perception of pain. In them the same strength of stimulus which in a typical case gives rise to the usual symptoms, does not cause abnormal reflex motor and secretory activity, and we do not have symptoms. Therefore these are the cases of ulcer in which there is no disturbance of "law of contrary innervation," and in which with every peristaltic wave the pyloric sphincter functions normally.

CASE REPORTS

CASE I.—W. M., age fifty-five, admitted to University Hospital, July 12, 1910. Until 10 A.M. he was perfectly well, never having had any previous abdominal symptoms. On admission entire abdomen was rigid, temperature 98.3, pulse 90, respirations 28. Operation by Dr. Muller disclosed a perforated duodenal ulcer which was sutured. No posterior gastroenterostomy was performed. Recovery uneventful and the patient was discharged on August 17, 1910.

CASE II.—M. W., age thirty-two, admitted to the Misericordiae Hospital, September 28, 1918, complaining of severe abdominal pain. He had never had abdominal symptoms until 4 P.M. of the previous day, when he began with generalized epigastric pain and vomiting. On physical examination the rigidity and tenderness simulated appendicitis. Operation by Dr. Muller. McBurney incision; appendix only slightly inflamed and not sufficient to cause the general fluid present in the abdomen. Appendix removed, wound closed, and right rectus incision made. All around the pylorus and duodenum was found a plastic yellow exudate and small pockets of fluid. No perforation could be discovered through the exudate. A posterior gastroenterostomy was impossible because of edema of the lower part of the stomach. The space between the liver was drained with two rubber tubes. The patient made a good recovery.

CASE III.—Mrs. J. V. R., age seventy-two, admitted to the Reading Hospital, September 30, 1918. Five days ago she was seized with acute abdominal pain and constipation. Cathartics were ineffectual. Patient had marked distention and borborygmi. Never had had abdominal symptoms before. Operation by Dr. Muller September 30, 1918. A perforation of the anterior wall of the duodenum about two and one-half inches from the pylorus was found and sutured. No drainage was introduced. Recovery uneventful.

CASE IV.—W. W., age thirty-two, admitted to the Medico-Chi Hospital, November 19, 1920. About 4 P.M., which was three hours after eating an egg sandwich, the patient was suddenly seized with

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acute generalized abdominal pain followed by vomiting. No previous history of any abdominal discomfort. Abdominal muscles rigid, some peristalsis, leucocytes, 22,000. Operation by Dr. Ravdin. A perforated duodenal ulcer, about two inches below the pylorus, on the upper duodenal wall, was found. This was sutured and a posterior gastroenterostomy was performed. Recovery uneventful.

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POLYPOID LIPOMA OF THE INTESTINAL TRACT

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THIS paper is based on the report of a case of lipoma of the ileocecal junction. The literature and the Bellevue Hospital records on this subject were also reviewed.

CASE I.—D. O., male, aged fifty-three years, Ire. Admitted to Bellevue Hospital May 28, 1920, complaining of pain in and about region of umbilicus. Four weeks before admission he began to have pain around navel. The pain would last from four to five seconds and feel like a sense of compression. He has been having several of these attacks every day. No blood in the stools. No belching of gas. No jaundice. No headache or impairment of vision. No genito-urinary or cardiovascular symptoms. No recent loss of weight. The patient has had a mass in the right inguinal region since a child. The mass often disappears by itself. At other times he can make it disappear. He was born without testicles in the scrotum. He is a well-developed male, well nourished, not acutely ill.

In the left side of the abdomen there is an oblong mass apparently involving the sigmoid, splenic flexure and descending colon. The abdomen is distended. The mass is evidently related to his attacks of pain.

May 30th had considerable pain in epigastrium. Bowels moved three times. Stool examined. Blood present. Abdomen distended, tympanitic but not rigid. The oblong mass persists in the left lower quadrant. No peristalsis seen.

Radiographic Report (June 4th).—No evidence of any obstruction of any portion of the colon. The colon is characterized by a central loop of the transverse portion. The haustra formation is very large. There is no defect in the outline.

Operation: Exploratory Celiotomy (June 7th).—*Resection of the ileocecal junction; end-to-side anastomosis.* A tumor mass was found in the abdomen in the region of the splenic area. On drawing it into the wound it was found to be an intestinal growth springing from the ileocecal junction. The mass itself was in the lumen of the intestine, apparently arising from the mesenteric attachment of the ileum and extending into the lumen of the large intestine. It was pyriform in shape, measuring about 7 x 6 x 5 cm., and having a distinct pedicle which infiltrated through the mucosa into the muscularis and serous coat of the intestine (Fig. 1). The free end of the mass had several small-sized knobs and cysts on it. At one side of the base there was a small bare area through the mucosa. Several large palpable lymph-nodes were found in the mesentery near the ileocecal junction. The appendix was

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quite long, congested and appeared pathological. There was no evidence of any intussusception at the time of the operation.

Procedure.—A 7 cm. median laparotomy below the level of the umbilicus was done. The tumor was found in the splenic region and brought into wound easily. After intestinal clamps had been applied above and below the ileocecal junction, an attempt was made to remove the growth through an incision in the lower ascending colon as the tumor was thought to be wholly cecal in origin. On opening the cæcum the pedicle was found to be implanted in the ileum and on trying to enucleate it, it was found that the growth extended through all three coats, and therefore a resection of the ileocecal junction was decided upon. We also had found several fairly large lymph-nodes in the mesentery close by, and the general appearance of the tumor mass made us believe the growth to be a malignant one. The resection of the cæcum and terminal ileum was accomplished fairly easily and an end-to-side anastomosis was done, implanting the ileum into the cæcum at the site of the original opening in the ascending colon. A large cigarette drain was introduced and the abdominal wall sutured in the usual manner. Condition of the patient at the end of the operation was good.

Pathological Report (by Doctor McWhorter).—Two specimens. One an apparently encapsulated tumor-like mass which measures 7 x 6 x 5 cm. The outer surface of this mass is covered with a large number of nodule-like projections which vary in size and shape. The whole surface appears to be covered by mucous membrane except one area. This tumor-like mass is attached to the surrounding tissue by a large thickened pedicle which measures 3 cm. in thickness. On section this specimen is seen to be surrounded by a rather thin dense outer covering. The substance of the tumor is composed of a soft yellowish tissue which resembles fat. The pedicle is made up of a very dense mass of connective tissue. The other specimen was the resected ileocecal junction. In the mass of tissue surrounding the intestine, there are a number of enlarged lymph-nodes which on section are of relatively normal appearance (Fig. 2).

Microscopical Examination.—Sections from the pedunculated tumor mass show the whole outer surface to be covered by mucosa, the glandular tissue of which in places is hyperplastic, while in other areas it is greatly hypertrophied. This glandular area is supported on a layer of connective and muscular tissues which somewhat resemble the normal muscularis. Extending inwards from this surface the tumor is entirely made up of a mass of adult fat which extends throughout the sections and is limited by the wall on the other side. Sections from the pedicle show a layer of dense tissue which somewhat resembles the muscularis. Beyond this there is a compact somewhat cellular mass of connective tissue which makes up the supporting pedicle. Sections show no evidence of malignancy.

Post-operative Course.—Patient had a slight post-operative reaction, developing some pulmonary congestion for several days, which gradually disappeared. The wound discharged for several weeks, at first the discharge being quite foul, but later with Dakinization of wound it cleared up rapidly.

He was discharged a month after the operation with the wound

healed and solid abdominal wall. His appetite was good, bowels regular and no blood in stools.

Follow-up Note (January, 1921).—Patient has gained about twenty-five pounds since the operation, feels fairly well, eats well, sleeps well, bowels regular without cathartics. Scar is solid, no evidence of post-operative hernia. Right inguinal hernia still present.

This case was extremely interesting from several viewpoints, anatomically, pathologically, and clinically. Anatomically, the patient showed distinct signs of incomplete development as evidenced by the undescended testicles, the congenital hernia, and the apparent incomplete rotation of the large intestine as shown at operation by the finding of the ileocecal junction in the splenic region and the presence of a long mesentery attached to the first portion of the ascending colon. Pathologically, the tumor as a gross specimen had all the appearance of a malignant growth, but on section and microscopically no evidence of malignancy could be found. Clinically, the extreme rarity of this condition and the difficulty of making a diagnosis on account of the position of the palpable mass and the clinical symptoms it gave.

REVIEW OF THE LITERATURE ON LIPOMA OF THE INTESTINAL TRACT

Pathology.—Lipomata may be developed from the submucous coat of the intestine and grow inwards or from the subserous layer and project outwards into the peritoneal cavity.¹ They may occur anywhere along the intestinal tract, but seem to be more commonly found near the ileocecal valve. They are usually single, but they may be multiple. Their size varies and they may be smooth, nodular, or lobulated. Senn² quotes Turner as having seen a fatty tumor the size of a walnut growing in the submucous tissue of the large intestine and projecting into the lumen of the bowel near the ileocecal valve. Ewing³ also reports having observed a large fatty tumor 4 x 10 cm. surrounding the appendix which was the seat of chronic inflammation. Bland-Sutton⁴ quotes Stabb who describes a tumor somewhat like ours. The tumor rose near the ileocecal valve and in size and shape it resembled three acorns conjoined at the cups. It had caused an intussusception of the bowel; this was reduced at the operation and the tumor excised. Unfortunately, the mucous membrane sloughed and the patient died.

Gant⁵ reports one case of a lipoma of the rectum. It was as large as a walnut and was attached to the rectal wall by a pedicle about 10 cm. from the anus.

The size of the tumor in our case was about 7 x 6 x 5 cm. and was pyriform in shape, and on its distal end it had many different sized nodules on it. The tumor itself had invaginated into the cæcum through the ileocecal valve.

These lipomata are considered extremely rare, being usually encapsulated and pedunculated, the pedicle infiltrating itself into the muscularis and connective tissue of the intestinal wall. None are reported as having shown any malignant changes. Ewing states Dewis collected forty-four cases of intestinal lipomata while Ehrlich collected fifty-two. Going over the Bellevue

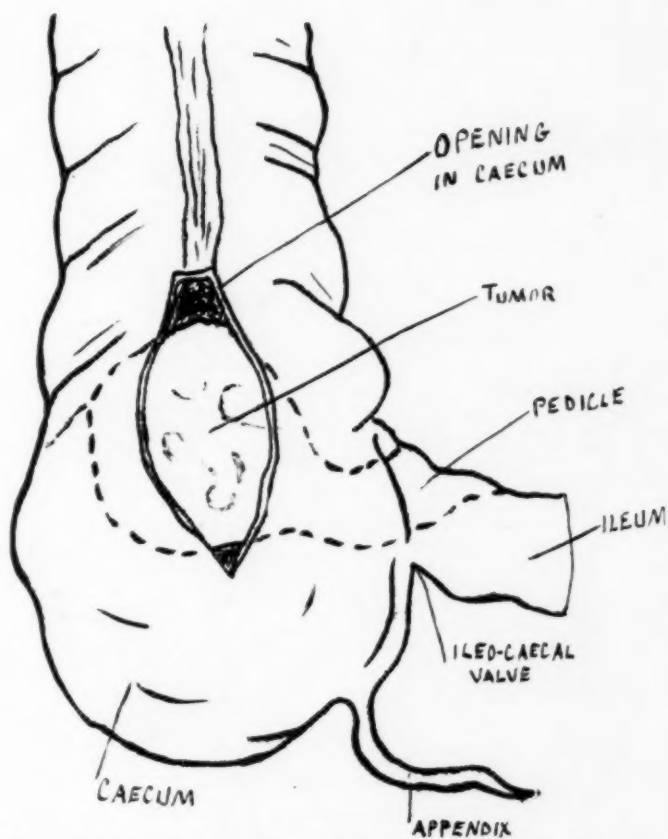


FIG. 1.—Diagram showing ileocecal junction with opening in it, disclosing the tumor free in the caecum. The rest of the tumor is shown in outline, the pedicle going through the ileocecal valve and is attached to the terminal ileum.

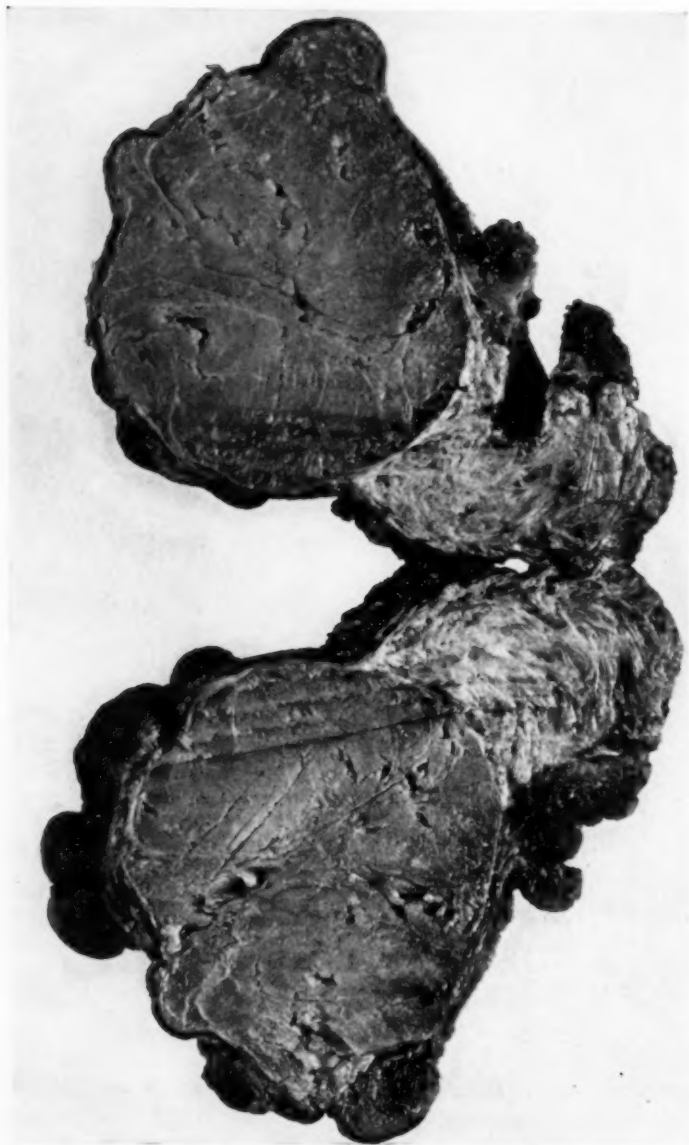


FIG 2.—Cross section of growth, actual size. The lipoma is distinctly shown to be circumscribed and completely covered by mucous membrane. The pedicle is also quite thick and infiltrates the intestinal wall.

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Hospital records from 1911 to 1920 we could only find one other case somewhat similar to ours. We examined the records of 601 cases of benign tumors that had been operated on. Of these eighty-five were lipomas, but none of them was intraabdominal. There were ninety-three cases of papillomas, nineteen being rectal polyps. None of the other benign tumors was found in the intestinal tract. We then examined the records of 120 cases of intestinal obstruction due to intraabdominal causes. Two of these were due to a malignant growth in the wall of the gut. There were twenty cases of intestinal intussusception, two of which were also due to a malignant growth in the wall. One case of intussusception was apparently due to a lipoma of the serous side of the intestine. On account of its similarity to ours it is reported in detail.

CASE II.—E. W., female, aged forty-three years, was admitted to Bellevue Hospital in Dr. C. McGuire's service on November 7, 1919, with the diagnosis of acute intestinal obstruction. She had been suffering from severe abdominal pain for four days. She stated that about three months ago she began to have severe abdominal pain, more pronounced in right lower quadrant, was nauseated but did not vomit. Pain would last about one day and would be relieved by a bowel movement. She would be free from pain for three or four days, sometimes a week. For the last month the pain has been more severe, more frequent every three days or so, the last attack being accompanied by vomiting. The patient claims this vomitus was brownish in color and had a horrible taste. Noticed blood in stools two weeks ago and twice since. Has not been able to retain food for the last three days.

Past History.—Negative except for removal of uterine tumor eight years ago.

Physical Examination.—Obese, well-developed woman in some pain. Temperature, 100°; pulse, 78; respiration, 24. Moderate distention of abdomen. No evidence of free fluid. No visible peristalsis. Tenderness on deep pressure, also rebound tenderness in right lower quadrant. No rigidity, no masses, no costovertebral tenderness. Pelvic examination negative. Rectal examination negative.

Operation (November 9, 1919).—Abdominal incision revealed an intussusception of the colon starting just distal to the hepatic flexure and ending at the first part of the sigmoid. The intussusception was gangrenous for about two inches at its apex. There was no polyp or growth in the lumen of the gut, but the apex of the intussusception had *on its serous surface a large round mass of pedunculated fat*. Many adhesions were present at the hepatic flexure. The sigmoid distal to the intussusception was collapsed. There was a good deal of free fluid in the right lower quadrant and it had a foul odor. A resection of the intussuscepted portion and a side-to-side anastomosis of the colon was done.

November 10th patient developed symptoms of paralytic ileus and a colostomy was done.

November 12th, died.

Pathological Report.—Specimen consists of a circumscribed apparently encapsulated lobulated mass which measures 8 x 9 cm. The outer surface is smooth yellowish in color. Attached to one surface there is a mass of brownish rather dense tissue. Section from the tumor mass is very soft yellowish in color and resembles fat. Microscopical section shows mass of adult fat to which is attached part of colon.

SYMPTOMATOLOGY.—As can be readily appreciated, these tumors do not give any symptoms *per se* except possibly a palpable mass in the abdomen. But as soon as they obstruct the lumen of the intestine or possibly cause an intussusception, then the symptoms of intestinal obstruction develop. These may be mild or acute, according to the degree of obstruction. During these attacks a mass is usually felt in the abdomen which may be the tumor itself, but more probably is obstructed faeces or the intussuscepted mass. The symptoms then may aggravate themselves as the obstruction becomes more complete and finally acute strangulation may occur. During one of these severe attacks the tumor may be expelled spontaneously by rectum. Dewis, in his forty-four collected cases, found that the tumor had been expelled spontaneously in nine and that intussusception had occurred in twenty-one cases.

In our case the symptoms were more of an intermittent obstruction type, due probably to the fact that the tumor arising from the ileum and having invaginated itself through the ileocecal valve it would at irregular intervals obstruct the flow of intestinal contents. As the peristaltic waves would force the tumor through, it must have necessarily caused a beginning intussusception of the ileum into the caecum. As the muscular action would let up for one reason or another, the tumor would drop back and the intestinal flow would be reestablished.

Diagnosis.—A positive diagnosis is practically impossible except possibly in the cases where the tumor is expelled by rectum. In the other cases the diagnosis will depend on the degree of obstruction, and therefore the most likely diagnosis will be either an intestinal obstruction due to a benign growth or an acute intussusception.

Radiographic examination of the intestinal tract may be of assistance or not, according to the amount of distortion the growth may cause in the outline of the gut. In our case neither the tumor nor any irregularity in outline was present in any of the radiographs taken.

SUMMARY

Clinically, therefore, these tumors may pass unnoticed, or their first symptom may be that of acute intestinal obstruction. Usually, though, the symptoms are more of an intermittent intestinal obstruction with acute exacerbations at infrequent intervals. A mass in the abdomen can be felt at times, especially when the symptoms are acute, but in most cases it disappears as these subside. As time goes on the attacks become more severe and may be accompanied by the passage of bright red blood by rectum, and finally complete obstruction occurs with all its attendant symptoms.

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At operation the operator must be guided by his pathological findings. The ideal operation would be an enucleation of the growth from the intestinal wall, but it may be necessary to do a resection of the intestine. This is due to the fact that on careful examination the pedicle of the growth is found to involve all the three layers of the intestinal wall. The resection should, therefore, be wide enough of the growth so that the whole pedicle will be removed. Other points to be considered in the resection, are the condition of the gut at the time of the operation; that is, if there is any intussusception of the intestine. In these cases the amount of resection would depend on the viable condition of the gut. Another condition to be considered is the location of the growth itself, for instance. If it is near the ileocecal junction, as in our case, it would be advisable to resect, as it would obviate the possibility of a constriction at an already narrow passage.

The post-operative course will again depend on the operative findings. If there was no obstruction the course will probably be a smooth one. If, on the other hand, there was an extensive obstruction and possibly an intussusception, the reaction will depend chiefly on the complicating conditions.

In closing I wish to express by thanks to Dr. F. St. John, Director of the First Surgical Division of Bellevue Hospital, for the privilege of reporting this unusual case.

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MYOMA OF THE RECTUM

REPORT OF FOUR CASES

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VERY few cases of benign tumors of the intestinal tract are reported in the literature. Heurtaux, Steiner, Dewis, King and others have written extensively on the subject, however, and have published cases of their own.

The tumors originate from the part of the intestinal wall which corresponds to the histologic structure of the various tumors; for example, adenomas from the mucosa, fibromas from the submucosa and serosa, lipomas from the fat cells of the external coat and from the appendices epiploicæ, angiomas from the vessels of the intestinal wall, and myomas, according to most investigators, from the muscularis or muscularis mucosa. In the benign tumors reported in the literature adenomas are the most frequent, angiomas most infrequent, and myomas comparatively infrequent.

In King's series of 119 cases the ileum and rectum are most often the sites of benign tumors. Dewis, in 1906, found 219 benign tumors of the intestinal tract, of which 101 were in the rectum; there were 81 adenomas, 10 myomas, 6 lipomas, 2 fibromas, and 2 angiomas. In Dewis' series were 40 myomas, 10 in the rectum and 30 in the remainder of the intestinal tract. In 1917 King reported a series which contained 45 myomas, of which 11 were in the rectum.

True myomas or pure muscle tumors are exceedingly rare; most tumors designated myomas contain varying amounts of connective tissue, and, depending on the relative amount of muscle and fibrous tissue, they have been called myomas, myofibromas, and fibrómyomas. The first true myoma of the rectum diagnosed as such was reported by Vander Espt in 1881. However, in 1872, Malassez had described a tumor of the rectum showing the structure of a myofibroma. In an extensive review of the literature only twenty cases have been found since 1872 which can be classified definitely as myoma or myofibroma of the rectum.

Myomas have been found throughout the entire gastrointestinal tract. Steiner collected twenty-one cases of myomas and myosarcomas of the stomach. The structure of these tumors is quite analogous to that of myomas of the uterus, and it might be supposed, because of the close proximity of the uterus and rectum, that the tumors in women are uterine in origin; however, the uterus was not found to be the origin in any of the reported cases. In eight instances the tumor originated from the anterior rectal wall, and in five instances, from the posterior wall. The part of the rectum involved in the others was not stated. The

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tumors varied in size from about 2 cm. in diameter to 12 pounds in weight, the largest extended down over the buttock, and was about 15 cm. in diameter.

Rectal myomas have been classified internal or external, according to their projection into the lumen of the bowel, or externally into the perirectal structures. Six were definitely pedunculated and extended into the lumen of the bowel, the remainder, apparently, were deeply imbedded and only encroached on the rectal lumen.

Many benign tumors of the intestinal tract are slow growing and symptomless; these are usually discovered accidentally in routine physical examinations or during operations for other conditions. Symptoms, when present, are usually mechanical, and are those of partial or complete obstruction; or hemorrhage occurs because of erosion. The predominating symptoms in the twenty cases were constipation, hemorrhage, and pain:

SYMPTOMS

	Cases
Constipation	12
Hemorrhage	7
Pain	7 ¹
Rectal pain	6
Abdominal pain	1
Obstruction	3
Rectal irritation	2
Desire to stool	2
Sensation of mass in rectum	2
Tumor known to be present	4
No symptoms	3

The infrequency of intestinal obstruction, considering the size and location of some of these tumors, is striking.

The diagnosis was based on microscopic findings in ten cases; the diagnostic data were not stated in ten.

DIAGNOSIS

	Cases	Microscopic	Not stated
Myoma	5	3 (Cases 2, 9, 15)	2 (Cases 3, 20)
Fibromyoma	12	5 (Cases 7, 8, 12, 14, 17)	7 (Cases 4, 5, 6, 10, 13, 16, 19)
Leiomyoma	2	1 (Case 11)	1 (Case 18)
Myoid	1	1 (Case 1)	0

The diagnosis in the four cases here reported was made by microscopic examination. Two of the tumors were true myomas and two were fibromyomas. In these cases, constipation, difficulty at stool, and hemorrhage were the predominating symptoms. In one case bleeding had been profuse to the extent of reducing the hæmoglobin to 20 per cent. at the

time of examination. The tumor originated from the anterior rectal wall in two cases and from the posterior rectal wall in two cases.

In the series of 20 cases reported in the literature and the 4 cases in the Mayo Clinic, 13 were females and 10 were males; the sex was not stated in one case. The youngest patient was twenty-one and the oldest eighty-five years; the average age was forty-five and three-fifths years.

AGES BY DECADES

Cases		Cases	
21 to 30 years	2	51 to 60 years	3
31 to 40 years	6	61 to 70 years	1
41 to 50 years	10	85 years	1

The tumors are often slow growing and may be present for years without symptoms. The duration of symptoms was stated in fifteen of the cases in the series.

DURATION OF SYMPTOMS

Cases		Cases	
Shortest	a few weeks	2 years	3
Longest	5 years	3 years	3
Less than 6 months	4	4 years	2
Less than 1 year	5	5 years	2

Malignant change may occur; it was seen in Case A55082. Ulceration of the overlying mucosa was a striking finding, but it is not diagnostic of any tumor of the rectum. The differential diagnosis includes all the benign tumors of the rectum and usually cannot be made accurately without microscopic examination. A smooth overlying non-infiltrated mucous membrane often is present and favors a diagnosis of benign tumor rather than malignant. In our cases there was a tendency to ulceration, and in one case extensive excavation into the perirectal tissues. The tumors tend to recur, usually due to incomplete removal or malignant change.

ABSTRACTS OF CASES IN THE LITERATURE

CASE I (reported by VANDER ESPT).—A woman, aged twenty-one years, in the seventh month of pregnancy noticed blood in the stools. She had also felt a tumor in the anus. At the time of delivery the tumor, about 3 cm. in diameter, appeared at the anus; it was smooth and bled easily from the covering of mucous membrane. The growth was removed by tying off the pedicle. Microscopic examination revealed smooth muscle fibres, and the growth was called a myoid.

CASE II (reported by TÉDENAT).—A man, aged forty-six years, entered l'Hotel Dieu de Lyon January 5, 1876. The patient was a full-blooded, vigorous man, who had lost blood from time to time during the preceding four years. Several hemorrhages had been very severe. He had had obstinate constipation, with a sensation of weight in the rectum, for five or six months before he came under observation. December 25, 1876, after he had been five days without bowel movement his abdomen was distended and tender to pressure and he had severe colic. Examination disclosed a hard tumor, about 0.5 x 1 x 2 cm., situated 5 or 6 cm. above the anal margin on the pos-

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terior wall. On cutting the tumor after its removal, irregularly disposed bundles of fibres and a few smooth muscle fibres were shown. A diagnosis of myoma was made. The patient made an uneventful recovery.

CASE III (reported by BERG).—A man, aged fifty-six years, had been constipated for about ten years, and had had several severe rectal hemorrhages. Rectal examination disclosed a hard, round tumor, extending into the posterior wall and encroaching on the rectal lumen. The overlying rectal mucosa was ulcerated. The tumor, a myoma, was definitely encapsulated, and was readily removed through a Kraske incision.

CASE IV (reported by SENN).—A woman, aged forty-five years, had been conscious of a small pelvic tumor for three years. While she was being attended for a miscarriage, the tumor was felt between the rectum and the uterus. It was firmly attached. After two years the abdomen began to enlarge, and the patient's general health declined. At the time of her examination, April 20, 1890, she was anæmic and emaciated, and her abdomen was distended with fluid. After the abdomen had been tapped and the fluid removed a large tumor could be palpated in the left lower quadrant of the abdomen. April 24, 1890, a laparotomy was performed, and a tumor was found attached to the anterior wall of the rectum by a pedicle at the peritoneal reflexion over the rectum. It was nearly globular, weighed 12 pounds, and a cut surface showed a true fibromyoma.

CASE V (reported by SENN).—A woman, aged forty-one years, was operated on through an incision in the vagina, and a fibromyoma about 3 cm. in diameter was removed from the anterior rectal wall.

CASE VI (reported by McCOSH).—A man, aged thirty-four years, complained of discomfort in the rectum and gradually increasing difficulty in evacuating the bowels. The stools had become thin and ribbon-like, and at the time he was admitted to the hospital he had had very little bowel movement for twelve or fourteen days. A hard tumor was found on the posterior wall of the rectum, extending from just above the anus to the hollow of the sacrum. The mucous membrane over the tumor was smooth but adherent to the tumor, which was smooth and regular in outline. The growth was thought to be malignant and a left inguinal colostomy was made. Later a hard, glistening, smooth tumor, adherent to the posterior surface of the rectum, was removed through a posterior incision extending from the anus to the coccyx. The enucleation was accomplished readily except at the attachment to the mucous membrane of the rectum, which was opened. Six weeks later the colostomy was closed. The tumor was about 10 cm. in diameter and proved to be a fibromyoma.

CASE VII (reported by HEURTAUX).—A woman, aged thirty-seven years, was seen August 18, 1887. She had always been in good health except for a tendency to constipation, which had been worse during the preceding three years. For a month before her examination she had a constant desire to move the bowels, and for a few days there had been symptoms of obstruction, that is, abdominal distention and colic, and vomiting, at times fecal. On examination a smooth ovoid tumor was palpated within the rectum. The tumor had a distinct pedicle and was firm and elastic. A diagnosis of myoma was made, and the tumor was removed by dividing the pedicle. The obstruction was relieved. The tumor weighed 90 gm. and was 8 x 6 x 4.5 cm. in diameter. Histologic examination revealed a fibromyoma.

CASE VIII (reported by HEURTAUX).—The patient, a woman, aged fifty years, was seen May 28, 1884. She had had attacks of intestinal obstruction for about ten days in 1872, and again in 1881. No further trouble occurred until May 28, 1884, when she felt severe pain in the anus and a pressing

desire to go to stool, with no result. A rectal examination was made and a hard, round tumor was found and extracted. It was nearly spherical, and measured 6 x 6.5 cm. Microscopic examination revealed a fibromyoma.

CASE IX (reported by WESTERMARK).—A woman, aged forty-nine years, had experienced occasional pain in the abdomen and sacral region, radiating down the thigh for a year and a half. She had had slight frequency and constipation. Examination disclosed a solid tumor in the right lower quadrant of the abdomen. An exploratory laparotomy revealed a soft, smooth, fluctuating tumor, about 16 cm. in diameter attached by a pedicle to the anterior rectal wall. Most of the tumor was lying to the right of the middle line. The patient died from obstruction, on the fifth day after the operation. The tumor proved to be a myoma.

CASE X (reported by RIEDINGER).—A woman, aged thirty-eight years, had had six normal deliveries and was at term at the time she was admitted to the hospital. She had been having abdominal pain for three weeks. Three abdominal tumors were palpable, and a diagnosis was made of ruptured uterus. At operation a transverse tear was found in the lower segment of the uterus and the foetus was in the peritoneal cavity. The patient died nine hours after the operation, and at necropsy an irregular fibromyoma 12 x 20 cm. was found adherent to the upper part of the rectum. It had originated in the rectal wall and was not connected with the uterus.

CASE XI (reported by LEXER).—A man, aged thirty-five years, had suffered from constipation for a long time, and had had several hemorrhages from the bowels in the course of a few weeks. Examination revealed a rectal tumor, fixed to the sacrum, just above the anal sphincter and extending higher than could be reached. The overlying mucous membrane bled easily. The tumor was enucleated with much difficulty by sacrificing the anal sphincter, which necessitated a sacral anus. A section of the tumor was reddish-gray. Microscopic examination proved it to be a true leiomyoma.

CASE XII (reported by CARLE).—A man, aged eighty-five years, complained of constipation, the sensation of a tumor in the rectum, and pain at stool. Examination revealed a tumor about 5 cm. in diameter encroaching on the rectal lumen from the posterior rectal wall 4 or 5 cm. above the sphincter. It was hard and covered by non-adherent, somewhat ulcerated mucous membrane. It was enucleated, and microscopic examination showed connective tissue with interposed groups of muscle fibres. A diagnosis of fibromyoma was made.

CASE XIII (reported by GRADENWITZ).—A woman, aged forty-one years, came for examination complaining only of lumbago. To the left and behind the uterus was a tumor 5 cm. in diameter, apparently connected with the uterus by a thin pedicle. The tumor was suggestive of a pedunculated submucous myoma of the uterus or a solid ovarian tumor. An attempt was made to extirpate the tumor through the vagina. On opening the peritoneum the entire posterior wall of the uterus was found to be intimately adherent thereto. The tumor was high in the rectum, and was enucleated after dividing the rectal mucosa. The tumor was a fibromyoma.

CASE XIV (reported by EARL).—A woman, aged forty years, was found, during labor, to have a tumor of the rectum. It was removed as the child's head approached the perineum. The tumor measured 8.7 x 6.5 x 5 cm.; it had only a membranous attachment to the rectum and was readily removed. It was composed of smooth muscle fibres, with a varying amount of fibrous tissue.

CASE XV (reported by BECKER).—A woman, aged forty-four years, complained of obstinate constipation, which had been worse during the last two

MYOMA OF THE RECTUM

years. Within a year she had noticed a tumor in the vagina. Examination showed that the posterior wall of the vagina was pressed forward by a tumor in the rectal wall, separate from the uterus. The tumor was about 8 cm. in diameter and was removed through a posterior incision. Microscopic examination showed it to be a myoma with very little connective tissue.

CASE XVI (reported by BALL).—In this case a fibromyoma was removed from the posterior wall of the rectum. The tumor, about 3 cm. in diameter, was sessile, and the overlying mucous membrane was freely movable. In structure it resembled a uterine fibromyoma.

CASE XVII (reported by DESCOEUDRES).—A woman, aged forty-six years, came for consultation because of a bulging in the vagina which she had noticed for several years. The tumor had gradually increased to about 10 or 12 cm. in diameter. The left buttock and the posterior surface of the thigh were enlarged. The mucous membrane of the anus was drawn out to cover a portion of the tumor, which was somewhat irregular, apparently multi-locular, and extended the entire length of the anterior and left wall of the rectum. The tumor was enucleated by blunt dissection and found to be attached to the rectum by a pedicle. It was a fibromyoma weighing 6 kg., and had undergone slight hyaline degeneration.

CASE XVIII (reported by VERHOOGEN).—A man, aged fifty-five years, entered the hospital because of constipation and severe rectal hemorrhage. On the anterior surface of the rectum, just behind the prostate, was a slightly movable, spherical tumor, about 10 cm. in diameter and covered by smooth, non-adherent mucous membrane. The tumor, which was causing entire obstruction of the rectum, was enucleated through a transverse perineal incision without injury to the rectal mucosa. It proved to be a leiomyoma.

CASE XIX (reported by CRIPPS).—A woman, aged forty-eight years, had suffered with slight bowel irritation for six months. Examination under ether disclosed a swelling about 2.5 cm. in diameter in the anterior wall of the rectum, 7.5 cm. from the anal orifice. This swelling was apparently in the muscular coat; the mucous membrane covering it was intact and was slightly movable over the mass. At operation the rectum was split in the middle line behind, and the tumor drawn down and dissected from the muscular wall. The growth was a thickened lump of the muscular coat converted into dense fibrous tissue.

CASE XX (reported by FINSTERER).—A man, aged fifty years, had had difficulty in bowel movements for six years, and passage of blood for six months. Examination revealed an ulcerated tumor, about 8 cm. in diameter, arising from the anterior wall of the rectum. The tumor was a myoma and was extirpated by removing the rectum.

CASES FROM THE MAYO CLINIC

CASE XXI (A53082).—A man, aged sixty-eight years, came for examination May 16, 1911. He complained of distress and dull pain in each groin, constipation, and urinary difficulty. Rectal examination showed a very hard mass, about 5 cm. in diameter, on the anterior rectal wall. The patient did not remain for further examination or treatment. He returned to the Clinic December 30, 1916. Constipation had persisted, and recently he had noticed that the rectum did not feel empty after stool. He had had acute retention of urine three times during the last three weeks, and frequency.

There was moderate hypertension, the systolic blood-pressure was 160, the diastolic was 105. The patient had a double inguinal

hernia. Rectal examination showed that the tumor had increased to about 10 cm. in diameter. It extended to the left and was outside the rectum.

January 11, 1917, the tumor was removed through the perineum without opening the rectum or bladder (E. S. Judd). The tumor bulged into the rectum and involved the rectal mucosa, starting just above the anus. The prostate could be felt above. The tumor was a fibromyoma and weighed 330 gm. The patient made a good recovery. He returned to the Clinic February 20, 1918, stating that he had had no urinary difficulty since operation, but that constipation had recurred. Rectal examination showed multiple small tumors of the anterior rectal wall. These were excised March 1, 1918. The specimens showed early sarcoma and the wound was left open for radium, which was given as follows: March 13, 1918, 500 mg. hours; April 20, 1918, 700 mg. hours; November 13, 1918, 400 mg. hours; January 14, 1919, 300 mg. hours, and February 4, 1919, 800 mg. hours.

At our last examination February, 1919, there were three nodules on the anterior rectal wall (Figs. 1 and 2).

CASE XXII (A115182).—A woman, aged twenty-eight years, was first examined in the Clinic June 7, 1916, when a diagnosis was made of inflammatory disease of the pelvis. She returned April 26, 1918, because of irritation in the left side of the rectum. There was tenderness in both vaginal fornices and an indurated mass in the rectovaginal septum. The patient was operated on June 6, 1918 (J. C. Masson). In exploring the rectovaginal mass it appeared to be inflammatory, but on microscopic examination of a specimen it proved to be a fibromyoma, apparently of rectal origin (Figs. 3 and 4).

CASE XXIII (A295358).—A man, aged fifty-nine years, was examined November 3, 1919. He complained of difficulty at defecation for the last six or seven months, and a feeling of obstruction in the rectum. There had been no bleeding nor diarrhoea. The systolic blood-pressure was 100, diastolic was 70. The temperature and pulse were normal. The urinalysis, the röntgenograms of the kidneys and bladder, the cystoscopic examination, and the blood Wassermann reaction were negative. The phenolsulphonephthalein output was normal.

The patient was sent in for operation (W. J. Mayo) November 18, 1919, with a diagnosis of rectal tumor, probably myoma. Exposure was obtained through a posterior incision with removal of the coccyx and terminal portion of the fifth rectal vertebra. The growth was posterior to the rectum, extending laterally toward the bladder and inside the true rectal fascia, evidently beginning in the non-striated tissues of the rectum; it was removed with the capsule, which was closely attached to the rectum. The tumor measured 9 x 6 x 6 cm. and examination showed cellular myoma.

The patient made a good recovery and was dismissed from the hospital on the tenth day, and from the Clinic on the twenty-fifth day after the operation (Figs. 5 and 6).

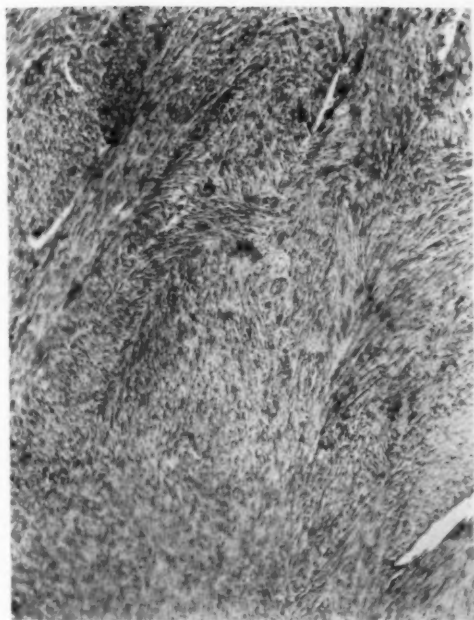


FIG. 1. (Case A53082).—Photomicrograph of fibromyoma of the rectum x 50.

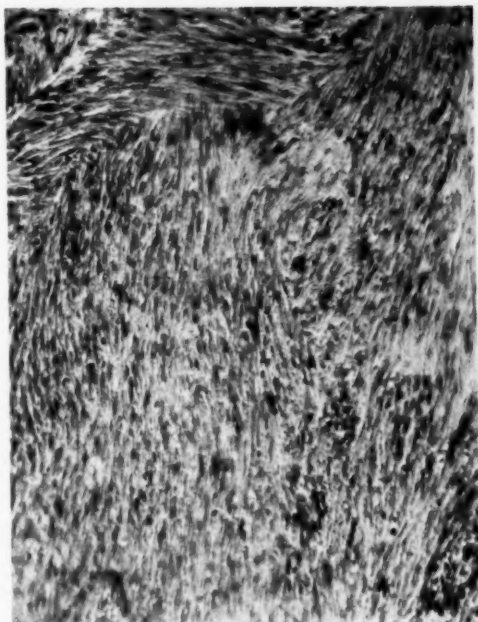


FIG. 2. (Case A53082).—Photomicrograph of fibromyoma of the rectum x 100.

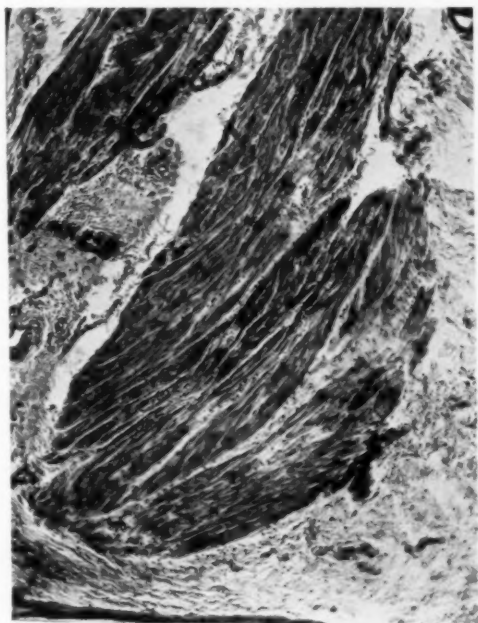


FIG. 3. (Case A115182).—Photomicrograph of fibromyoma of the rectum x 50.



FIG. 4. (Case A115182).—Photomicrograph of fibromyoma of the rectum x 100.

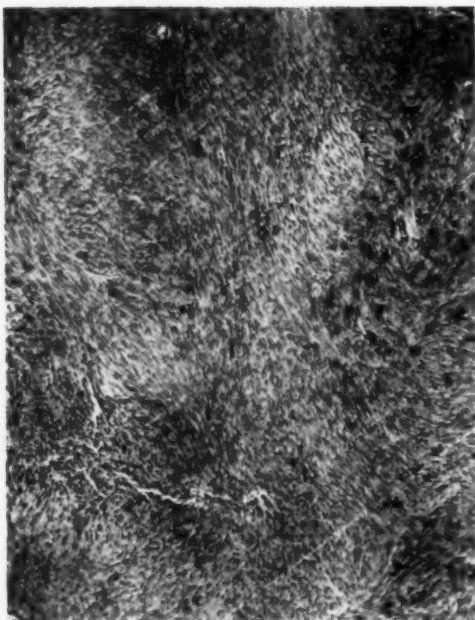


FIG. 5. (Case A295358).—Photomicrograph of myoma of the rectum $\times 50$.

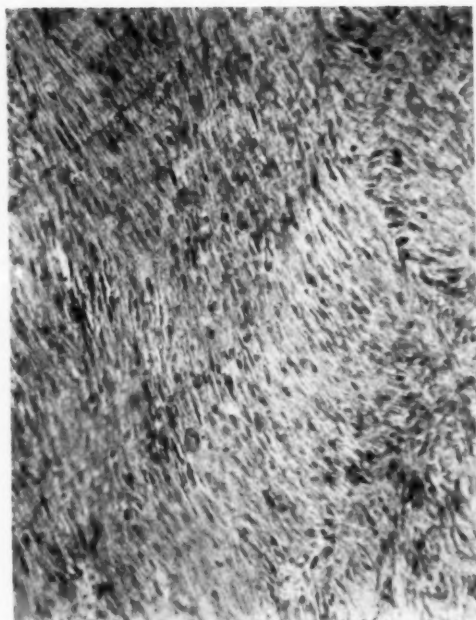


FIG. 6. (Case A295358).—Photomicrograph of myoma of the rectum $\times 100$.

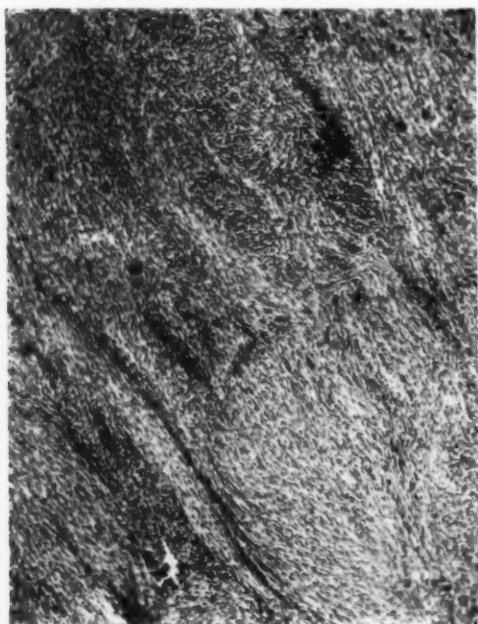


FIG. 7. (Case A308866).—Photomicrograph of myoma of the rectum $\times 50$.

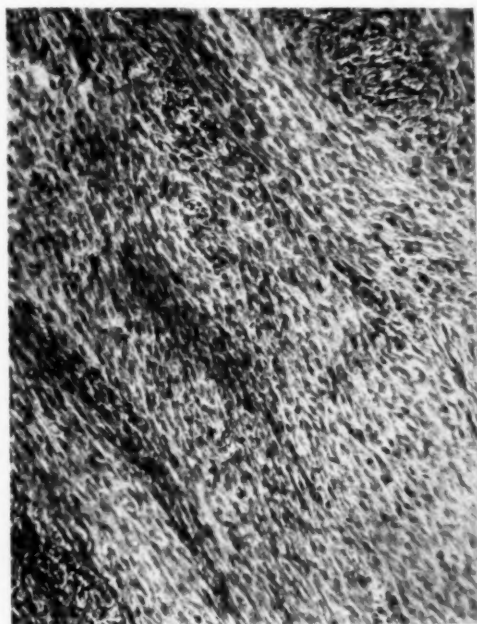


FIG. 8. (Case A308866).—Photomicrograph of myoma of the rectum $\times 100$.

MYOMA OF THE RECTUM

CASE XXIV (308866).—A man, aged thirty-four years, had had three operations on the rectum elsewhere for tumor believed to be cancer. The last operation was performed January 15, 1920. He presented himself at the Clinic March 18, 1920, with the following history: In 1915 he first noticed difficulty in moving his bowels; this condition grew progressively worse and was associated with some pain. In 1916 he had an operation for hemorrhoids, with relief for one year. A diagnosis of cancer was then made and a second operation performed, followed by improvement for two years, when the symptoms recurred. Two operations were performed in January, 1920, procedures not stated. Blood had been noted in the stools at various times. The patient had not lost weight, and his general health was good.

At the time of examination the patient weighed 175 pounds; he was very pale. The systolic blood-pressure was 126, the diastolic was 78. There was a slight systolic murmur at the apex. About 2.5 cm. above the anal sphincter was an excavated mass involving chiefly the left rectal wall and extending up into the rectum about 10 cm. The mass was ulcerated and bled readily and extended into the perirectal tissues. The mucous membrane over the growth was smooth and not infiltrated. The tumor was thought to be non-malignant and inflammatory.

Operation was performed March 20, 1920 (V. C. Hunt). The anal sphincters were divided posteriorly, and a specimen of the growth removed for microscopic examination. The tumor, which proved to be a myoma, was entirely removed by enucleation and the cavity packed with iodoform gauze. The patient made a satisfactory convalescence. Radium was given rectally as follows: March 29, 1920, 560 mg. hours; April 2, 1920, 1160 mg. hours; April 5, 1920, 1762 mg. hours, a total of 3482 mg. hours. The patient was allowed to go home, but was advised to return in three months. July 6, 1920, the rectal mucous membrane was smooth, and there was no evidence of recurrence. The sphincters were somewhat weak, resulting in partial incontinence. The hæmoglobin was 44 per cent. Recent letters from the patient and from his local physician state that there is no recurrence. The patient is to return to have the sphincter muscles repaired (Figs. 7 and 8).

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TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY

Stated Meeting Held March 23, 1921

The President, DR. WILLIAM A. DOWNES, in the Chair

ACUTE HÆMATOGENOUS OSTEOMYELITIS

DR. F. W. BANCROFT read a paper with the above title, for which see page 681, June, 1921, lxxiii. He presented lantern slides and two children in connection with the paper.

SUB-TOTAL GASTRECTOMY FOR EXTENSIVE TUBERCULOSIS OF THE STOMACH

DR. EDWIN BEER presented a young colored man, twenty-one years of age, who was admitted to the service of Doctor Abbott, at Bellevue Hospital, on November 3, 1920. His chief complaint was vomiting for a period of three months. He had lost in last three months twenty-three pounds. He had had no previous diseases, but five years prior to admission he had a sore on the penis which lasted two to three weeks and was complicated with suppurative bubo. No secondaries developed and blood examination made three months before admission was negative. Wassermann was ante-complementary. His present trouble had begun two years ago with attacks of pain in the epigastrium. These attacks have become much more frequent during the last three months. Now he is troubled with vomiting every day, which comes a few minutes to several hours after eating, and often vomits food taken on the previous day. At present, no nausea or pain, never vomited blood, bowel normal. No jaundice and no urinary symptoms. Physical examination showed an emaciated, underfed young man. The examination of the chest showed râles and impairment of breathing at both apices. Abdominal examination showed distinct enlargement of the stomach with large and visible peristaltic waves which passed from left to right towards the pylorus. X-ray examination of the stomach showed marked stenosis of the pylorus with dilatation of the stomach. Sputum examination was negative for tubercle bacillus. X-ray examination of the chest showed no evidence of tuberculosis. The patient was transferred to the surgical side. It was suggested that he be given gas-oxygen on account of his possible pulmonary involvement, in spite of the negative X-ray findings and sputum. On November 15, 1920, operation by Doctor Beer. Right upper rectus incision exposing the stomach, at the pyloric end and involving the antrum there was a large tumefaction about the size of an adult palm with many dozens of enlarged glands along the lesser curvature and along the greater curvature. The mass in the stomach was freely movable

and very firm, and gave the impression of being a malignant growth. A wide rapid excision of the involved area and the enlarged glands was made with the cautery technique. The duodenal stump was inverted and covered with the pancreas. The cardiac stump was closed with several layers of sutures after dropping the male half of a Murphy button into this end of the stomach. Then an ante-colonic, long loop, anterior gastro-jejunostomy with Murphy button was done, using the half of the button that had been dropped into the stomach for the anastomosis. Patient made an uneventful recovery and was discharged from the hospital November 27, 1920, with the Murphy button still in place. The report of the pathologist, Doctor Symmers, upon the mass removed is:

Specimen consists of a mass removed from the stomach. The mass measures about 10 cm. in length and 16 cm. in breadth. For purposes of description, it is divisible into two portions—an upper, which consists of gastric mucous membrane thrown into large folds, and a lower, in which the walls of the stomach are thickened to the extent of from 1 to 1 1/4 cm. On section the cut surface of the stomach wall in this locality is perfectly smooth, firm and dead white. It is surrounded on the inside by mucous membrane which is thrown into numerous large folds, and from which numbers of small teat-like polypi project. The mucosa covering the lower few cm. of the stomach is superficially eroded.

Microscopic examination of the lower portion of the stomach, corresponding to the thickened walls described above, shows the presence of superficial erosion of the epithelial tubules. The most striking feature in the histologic picture, however, consists in extensive round-cell infiltration, the infiltrating cells consisting partly of lymphocytes and partly of plasma cells. Scattered through the deeper portions of the stomach wall are numbers of typical epithelioid tubercles.

The specimen is accompanied by many enlarged lymph nodes. One of these, on microscopic examination, shows many epithelioid tubercles.

Diagnosis: Hyperplastic tuberculosis of pyloric region of stomach; tuberculosis of perigastric lymph nodes.

DR. WM. A. DOWNES recalled that several years ago Doctor LeWald and he had reported several cases of syphilis of the stomach, which clinically were proven cases of syphilis of the stomach. He removed a specimen from one case and sent it to Doctor Wood for examination. Doctor Wood would not commit himself absolutely, but he described the pathology in detail, and stated that while there was resemblance of tuberculosis he felt that the condition was syphilis rather than tuberculosis. Indeed, frequently it was difficult to distinguish between tuberculosis and syphilis of the stomach. In these cases in which Doctor Wood would not commit himself gastroenterostomy was performed and antisiphilitic treatment instituted and they had remained well. If it had been a tuberculous condition it seems that it would have been progressive, though possibly it might have become latent. At any rate all of these patients had gained in weight, and one had given birth to a baby.

Doctor Beer said he had no idea at the time of operation that it might be tuberculosis, but thought that it would be carcinoma or lymphosarcoma. If he had thought of the possibility of its being tuberculosis he would have prevented the specimen being damaged by formalin. That was unfortunate because formalin hardened the specimen so that it was difficult to find the tubercle bacilli.

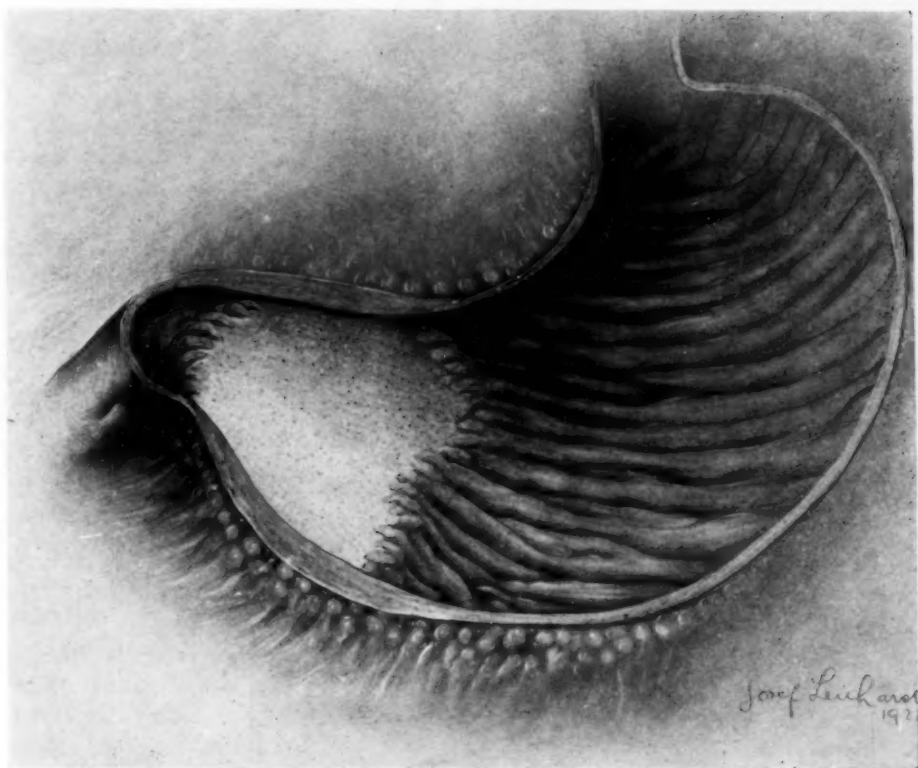


FIG. 1.—Tuberculous ulcer of stomach. Sketch showing position of enormous, tuberculous ulcer with almost smooth surface which involved the whole antrum, anterior and posterior walls, beginning close to the pylorus and extending well up into the body of the stomach with innumerable glands in the lesser and greater curvatures, removed by sub-total gastrectomy.



FIG. 2.—Sketch of hydro-nephrotic kidney and hydro-ureter exposing at the lower end of the ureter, which has been opened, a primary benign papilloma 7 cm. from bladder. Specimen removed at operation by aseptic nephro-ureterectomy without opening the upper urinary tract.

ASEPTIC NEPHRO-URETERECTOMY

ASEPTIC NEPHRO-URETERECTOMY FOR PRIMARY PAPILLOMA OF THE URETER

DR. EDWIN BEER presented a man, sixty-one years old, first seen February 4, 1920, for hæmaturia. He had had four attacks, the first twelve months ago, and then every three to four months thereafter. No pain accompanied bleeding. The blood was bright red and clotted. There was no obstruction to outflow from the bladder; frequency was practically normal, at night one urination. Past history of ulcer of the stomach and chronic bronchitis and emphysema. No recent loss of weight.

February 4, 1920. Cystoscopy performed while not bleeding showed the following:

Stricture of the deep urethra, which bled on stretching; intra-urethral and vesical adenoma formation of prostate which bled readily; fair-sized diverticulum in anterior bladder wall whose interior could not be completely inspected (hidden tumor); good indigo output from left kidney, none seen coming from the right; specimen from left full of blood-cells, probably traumatic, no obstruction on this side; obstruction on right side at 8 cm. and no specimen obtained. After withdrawal of the catheter from the right ureter there was a continuous flow of blood from this side. Palpation suggested enlarged right kidney.

D. D. Stone in right ureter, tuberculous stricture, tumor of the ureter. X-ray was negative for stone and no TBC could be recovered. To determine accurately the source of hæmaturia the patient was instructed to return during attack. After several attacks he came in with his bladder full of clots which he could not express. After emptying his bladder October 18, 1920, it was evident that the blood came from the right ureter which was obstructed at 7 cm. On the strength of these findings the diagnosis of tumor of the right ureter was probable, and the possibility of the original growth being in the pelvis was considered as likely. Therefore a nephro-ureterectomy without opening the urinary channels was advised. Owing to the patient's poor general condition there was some hesitation as to the advisability of going ahead. Finally, however, the operation was decided upon not only to get rid of the source of bleeding, but to obviate the possibility of being forced to do a palliative cystostomy to empty his bladder of clots which he had been unable to void because of his considerably enlarged prostate.

December 1, 1920. Under gas-oxygen the kidney was exposed and found to be markedly hydronephrotic with dilated ureter. The vascular pedicle was tied and the large ureter was freed well down across the pelvic brim, a silk ligature applied to same for purpose of identification, then the patient was rolled partly on his back and the pelvic ureter was exposed through a paræctus extraperitoneal incision and ligated well below the tumor which could be distinctly felt in the lower ureter. At the site of the growth the ureter was firmly adherent to the pelvic wall. After doubly ligating the ureter near the bladder, it was cut between and by traction on the silk ligature placed on the ureter through the lumbar wound, the whole ureter and hydronephrotic kidney were withdrawn in

one piece and unopened. The patient made a rapid convalescence.

The specimen showed a fair sized hydronephrosis and hydro-ureter with a papillary growth near the lower end. The microscopic report by Doctor Mandelbaum stated that the growth was benign.

SUBCUTANEOUS RUPTURE OF THE SPLEEN

DR. JOHN F. CONNORS read a paper with the above title and presented two patients in illustration of the subject.

DR. JAS. M. HITZROT said it was a curious fact that when the profession knew but little about any given organ that the theories regarding the effect of its removal were apt to be quite numerous. The splenectomized individual was stated to be prone to infection, less resistant to hemorrhage, more subject to new growths, even less amiable in disposition, yet there was a complete failure to demonstrate any of these factors as having occurred in the human individual who had lost a normal spleen. The Society would perhaps recollect that Doctor Downes presented a case of spontaneous rupture of the spleen in the third week of typhoid fever, in which the patient made a normal recovery from typhoid. The patient also recovered from a cellulitis of the cheek, a peritonsillar abscess, and from the extraction of a tooth in what could easily be said to be a normal interval.

Doctor Hitzrot said he did not believe that it had been demonstrated that the function of the spleen was not rapidly compensated for by other organs and that within a very short interval following the splenectomy. If the spleen acted as a storehouse for antibodies formed after an infection, it would seem that these antibodies were rapidly stored elsewhere after splenectomy. Pearce and his collaborators were of the opinion that the splenectomized individual suffered more severely from hemorrhage and recovered more slowly from the effects of hemorrhage than the normal individual, but other than that Doctor Hitzrot believed that little else occurred.

The question of partial splenectomy, tamponade, etc., deserved no discussion, as it was much easier to remove a spleen than to resect it, and much safer to remove it than to depend upon packing or upon suture to control the hemorrhage.

As to the question of the hypertrophy of the hemolymph glands or accessory spleens it was yet to be proven that this process occurred. In one of Doctor Hitzrot's patients, submitted to a second operation for a lower abdominal lesion in which a previous splenectomy had been done and in which these small reddish bodies had been noted along the splenic vein, palpation of the area of the vein at the second operation did not demonstrate any enlargement of these structures. While Doctor Hitzrot could not actually see them, they did not feel increased in size.

For evidence of the importance of the spleen in the infections the recent work of Morris and Bullock (*ANNALS OF SURGERY*, vol. xxxvii, page 513, et seq.) should be consulted. Their conclusions, at least for rats, differ from that observed by Doctor Hitzrot for the human individual, and the operative

SUBCUTANEOUS RUPTURE OF THE SPLEEN

wound produced to remove the spleen healed as kindly as any other wound of similar character, even in the anæmic individuals so frequently submitted to the operation of splenectomy.

DR. EDWIN BEER said that, though the spleen was usually more easily removed than resected, occasionally it was possible to save injured organs by using a technic that had been very useful in kidney operations. In operating upon the kidney, liver or spleen, the stitches often did not hold well and were liable to cut in, thus not controlling hemorrhage. To prevent sutures cutting into these viscera he has used underpinning with fair-sized pieces of fat, usually taken from the wound. The double-threaded straight needle pierced the organ, and as the knots were tied at the entrance and exit of suture they were tied over a piece of fat. In this way the vascular tissue could be compressed between the wads of fat without the thread cutting into the tissue.

DR. ROBERT T. MORRIS called attention to a point in the technique in cases in which there was a large amount of blood in the peritoneal cavity. This blood was still in the circulation in a way because it was in the large lymph chamber. When one opened the peritoneal cavity the patient sometimes bled to death because of the turning out of a large amount of blood. Clots only should be removed. The opening of the peritoneal cavity introduced a critical moment and one could carry the patient over this time of danger by having saline solution at hand and the needle already in the vein in the arm; the infusion of saline should begin at the very moment of opening the peritoneal cavity.

Doctor Morris said he had used decalcified bone in the same way as Doctor Beer described using the fat pads in operating upon both the liver and the spleen. Decalcified bone gave a broad firm support for the through and through sutures.

DR. FRANK S. MATHEWS said there was an impression that bleeding into the peritoneal cavity was a total loss of blood to the patient. Doctor Sweet, of Philadelphia, had performed the experiment of putting blood into the peritoneal cavity of animals and in a short time found the red cells in the thoracic duct. It is a waste of time to remove all the blood from the peritoneal cavity. One may remove the clots and leave the fluid blood, and in a short time the red cells will be returned to the circulation. Of course, if infection is present, there will be an additional reason for removing the blood.

DR. THEODORE DUNHAM remembered that a peculiarity of Dichloramine-T is that when it is not pure the impurities are generally of such a nature that they are particularly harmful. Free hydrochloric acid and free chlorine are apt to be given off. When present in any considerable amounts, these emanations are very damaging to the living tissues, sometimes more harmful than the germs we are trying to destroy. Fortunately, these impurities are revealed by a pungent smell. Pure Dichloramine-T has a very mild chlorous odor, which is neither disagreeable nor repellent. As these impurities are very volatile, a bottle of inferior Dichloramine-T may have a pungent odor when freshly opened, from an accumulation of these gases, but lose most of its

pungency after it has been opened or the cork left loose for a time. Such a sample had better not be used. One is safe if the substance is in the form of clean crystals and the freshly opened bottle gives forth only a very mild chlorous odor.

The quality of the Chlorcosane is also of great importance. Some samples have a more viscous element suspended in them or clinging to the inner surfaces of the bottle. Such samples are, I think, not properly chlorinated and are liable to take chlorine from the Dichloramine-T and so decompose it. A really good Chlorcosane is a practically clear and homogeneous fluid and only such, I think, should be used.

In making up the solution of Dichloramine-T it should not be forgotten that water decomposes it. It is best thoroughly to dry by heat the vessel in which the Chlorcosane is measured, in which the Dichloramine-T is weighed and dissolved, and the bottles in which the solution is kept. Sunlight and electric light decompose Dichloramine-T. The more impure the ingredients, the more quickly will light decompose the solution.

A solution made carefully from good materials and shielded from light will keep clear and good for months.

He had used Dichloramine-T in a great variety of wounds. A 5 per cent. solution is particularly useful in situations where it is important to have an antiseptic travel along a very tenuous channel and there maintain an antiseptic power. In cases of infection at the side of the finger nail or toe nail this oily solution will often find its way down a crack and sterilize the infected region without painful procedures. So, too, where the proximal part of the nail is removed to reach an infected area, or where this end of the nail can be lifted up, the oily fluid will insinuate itself and often do excellent work without any smarting. Where a splinter has run far under the nail and broken off, he had shaved away enough of the nail to grasp and withdraw the splinter and then applied the oil. He could look through the nail and see the oil run by capillary action and fill up the space from which the splinter had been withdrawn, and this with no attendant pain or future incident. In a recent and inflamed puncture wound of the hand with a tract about an inch in length, he worked the oil along the length of the tract with a silkworm-gut drain. The swelling and other signs of inflammation subsided without any cutting being necessary.

For many purposes Dichloramine-T is of course not as good as other antiseptics, but for certain situations it has no equal. What he most particularly wished to emphasize was the importance of using a pure solution.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting held April 4, 1921

The President, DR. GEORGE G. ROSS, in the Chair

FRACTURE OF THE METATARSAL BONES

DR. EMORY G. ALEXANDER read a paper with the above title, for which see page 214.

DR. ARTHUR B. GILL remarked that it is essential after fractures of the metatarsals to support them on the plantar side by some form of arch support. For this purpose he used hard felt pads. It is rather remarkable what little disability patients have, who have suffered from more or less severe fractures of the bones of the foot, if care has been taken during the treatment to preserve the proper arch of the foot and to prevent pes valgus or pes varus. Accurate re-position of fragments of the tarsus and metatarsus seems to be unnecessary if the proper position of the foot is maintained with reference to weight-bearing.

From the operative procedures which are done upon paralytic feet surgeons have become familiar with the resistance of the foot to severe operative traumatism. In subastragalar arthrodesis and in horizontal transverse section of the foot a large amount of traumatism is inflicted upon the bones and even upon the soft parts without subsequent infection or necrosis and sloughing. The considerations in treatment of the foot are the preservation of the normal arch and the maintenance of the foot in such position that the weight-bearing line which comes down along the crest of the tibia should fall centrally in the foot.

When the fracture of the metatarsals is very close to the head so that a small fragment of bone is displaced laterally or to the plantar aspect, it is better to excise this fragment. This Dr. Alexander did in one of his cases. Such excision can probably best be done through a circular incision on the plantar surface of the foot just back of the toes.

RUPTURE OF UTERUS DURING ATTEMPTS AT VERSION

DR. ASTLEY P. C. ASHHURST reported the case of a woman, forty-one years of age, who was admitted to the Abington Hospital on December 28, 1920, with the diagnosis of ruptured uterus.

The woman had given birth to nine children, all at term. These births

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were all normal with normal puerperal period. Her tenth labor began December 26, 1920. Having not been able to deliver herself by the following day she summoned her family physician, who finding a shoulder presentation, attempted a version, but without success. Another physician was called in consultation, and under nitrous oxide analgesia, version was twice again attempted. At the end of the second attempt the patient suddenly went into collapse.

One hour later Dr. Ashhurst saw the patient and noted the following: Expression anxious, air hunger with no abdominal breathing, skin moist and cool, pulse very rapid and thready, abdomen distended and tender to touch. There was a large irregular mass in the epigastrium which could be recognized as a foetus. The uterus could be readily palpated, and found well contracted, with the fundus a hand's breadth above the symphysis.

Under nitrous oxide anaesthesia the abdomen was opened by a right paramedian incision 15 cm. in length. A large quantity of blood was evacuated. The uterus was delivered, and grasped just above the cervix to prevent further bleeding. A rupture 9 cm. long was found in its mid-line on the posterior wall. The foetus and placenta were found free in the epigastrium and removed. Clamps were applied to the broad ligaments, and a subtotal hysterectomy was done. The stump was closed with continuous chromic gut sutures; uterine vessels ligated; edges of broad ligaments brought together by a continuous sero-serous suture of chromic gut; stump covered with peritoneum in same manner; abdominal cavity flushed with normal saline; cigarette drain carried down to stump of cervix; abdomen closed in layers.

With the maximum amount of stimulation, repeated hypodermoclysis, continuous enteroclysis, and with all due credit to her natural resistance, she began to improve after the first twenty-four hours. From this time on convalescence was uninterrupted, and she was discharged as cured thirty days after operation.

Histologic examination of the uterus showed an occasional ruptured muscle fibre with a mononuclear infiltration.

DOUBLE AMPUTATION OF THE THIGH FOR SENILE GANGRENE

DR. ASTLEY P. C. ASHHURST presented a man seventy-two years of age, who was admitted to the Episcopal Hospital October 3, 1920, with a diagnosis of gangrene of left foot.

Patient stated that two weeks ago he began to have a burning pain with tingling from toes to knee on left. A day or so later he noticed that his toes on that side were reddened. This color soon changed to a purple, and at the same time the pain disappeared. Examination showed the foot and toes cold and purple in color. Slight pitting on pressure. No pulsation could be felt over the popliteal, dorsalis pedis, or posterior tibial arteries. There was swelling, pain, and beginning redness of the toes of the right foot, with absence of arterial pulsation.

On October 8, 1920, the left thigh was amputated in the lower third. On

AUTOTRANSFUSION

examining the stump it was found that the femoral artery was thrombosed. When the tourniquet was removed there was little or no bleeding from collaterals. The femoral artery was then dissected up to a point where pulsation was found, and the ligation made at this point. The smaller vessels were ligated, sciatic nerve drawn down and cut, rubber tube drainage instituted, and the skin flaps loosely brought together with interrupted silkworm sutures. Patient returned to bed with stump elevated and heat applied.

On October 22, 1920, Dr. Ashhurst amputated the right thigh in the lower third. Again femoral artery was found thrombosed, and only slight oozing from collaterals. Muscles closed over stump with mattress sutures of chromic gut. Skin closed transversely with interrupted silkworm sutures. Rubber tube drain at outer angle of wound.

For several weeks following the operation the patient was irrational. During this time he repeatedly removed his dressings which resulted in a superficial infection of both stumps. This cleared up, and he went on to a complete recovery.

Laboratory findings: Wassermann negative. Urine negative. Histologic examination of specimens showed marked arteriosclerosis.

AUTOTRANSFUSION

DR. FRANCIS C. GRANT presented a man forty-two years of age, who was admitted to the service of Dr. C. H. Frazier at the University Hospital, presenting a clear-cut picture of cerebellar tumor. A suboccipital exploration was determined upon. It had been their routine practice of late to transfuse postoperatively all cases upon whom a suboccipital exploration has been performed. The procedure is of necessity a prolonged one accompanied by considerable shock to vital centres, and they had found that immediate transfusion insured a prompt reaction and improved the postoperative course. The patient in question had no money to pay for a donor and was of type 3, the least frequent type. They had no donors of this type on their free list. However the patient was large, stout, and plethoric. His B.C.R. totalled, 6850,000 with 110 per cent. Hgb. confirmed by several counts. Robertson, Rous and Turner, and others had shown that whole blood could be kept citrated and cold for a considerable time. From observation upon six donors they knew that following the withdrawal of 500 c.c. of blood the cell count and hæmoglobin returned to normal in five to nine days.

The patient was definitely plethoric, his blood pressure was 155 systolic and 110 diastolic. In view of the fact that they could not obtain a suitable donor and that transfusion would be desirable following his operation, it was suggested that they bleed the patient, allow him twenty-four hours to recover from the transfusion, operate upon him, and transfuse him with his own blood. This was accordingly done. The blood was obtained, kept in .2 per cent. sodium citrate solution in a refrigerator and retransfused following operation. Three hours after operation the temperature, pulse, and respiration were 100, 118, and 18, the highest point reached. Clinically no reaction was

noted. The postoperative course was favorable. Four days after operation the R.B.C. were 4,919,000, Hgb. 90 per cent and blood pressure 135-100.

In conclusion, they suggest that although the plethora and high blood pressure seemed special indications in this case, autotransfusion might be considered in other conditions. In cases where a donor cannot be obtained for any reason and in which a patient with a high normal blood picture faces an operation known to be attended with shock and hemorrhage, if he be bled sufficiently far enough in advance of his operation to allow his blood picture to return to normal, this blood may be kept with safety and retransfused at a time when such a procedure may be life-saving.

AMCEBIC ABSCESS OF THE LIVER

DR. ADRIAN W. VOEGELIN read the history of a case of abscess of the liver to illustrate the importance of early recognition and operation of such cases.

C. G., a male, aged thirty-five, was admitted to the Episcopal Hospital on January 3, 1921, complaining of pain and swelling in the right upper abdomen. He remembered having been ill seventeen years ago with a persistent diarrhoea. No other history of dysentery could be obtained. One year before admission he had been in another hospital where an abscess of the liver was incised. Culture of the pus was negative and the nature of the abscess was not determined. Three months before the present admission he began to suffer pain in the region of the old scar, and developed a gradually increasing swelling. The patient was extremely emaciated. No jaundice was present. In the upper right abdomen, just below the ribs, was a rounded swelling quite tender and tense on palpation and evidently containing fluid. The skin was slightly reddened and a small scar about two inches long was to be seen. The edge of the liver could not be felt. Further examination of the abdomen was negative. Temperature, 98°; pulse, 92; respirations, 22. The blood examination showed: Hæmoglobin, 70 per cent.; erythrocytes, 3,870,000, and leucocytes, 20,200, of which 83 per cent. were polymorphonuclear, 8 per cent. mononuclear, 8 per cent. lymphocytic, and 1 per cent. transitional cells. No amœbæ could be found in the stools.

On the day after admission, the patient was operated upon under gas anæsthesia by Dr. E. G. Alexander. A right rectus incision about four inches long was made, opening the peritoneal cavity, which contained a little sterile serous fluid. A swelling about the size of a fist, projecting anteriorly, was found on the surface of the liver. As but few adhesions were present, the opening of the abscess was postponed, and, after walling off the peritoneal cavity with gauze packing, moist dressings were applied to the open wound. Forty-eight hours later, an abscess cavity, about five and one-half inches in diameter and occupying most of the right lobe of the liver, was opened with a cautery knife, and evacuated of over three pints of viscid brownish fluid which contained much fine granular detritus, a trace of bile and few pus cells, and gave no growth on several culture media. A large rubber-tube drain was inserted and gauze packing and dressings applied. The patient's

PERFORATED GASTRIC AND DUODENAL ULCER

temperature rose to 103° , but gradually came down to normal within a week without any signs of peritonitis having developed. Curettings taken from the abscess wall two days after evacuation showed many motile amoebæ on the warm microscope stage. The pus which drained away gradually became thinner, and ceased shortly after the first week, when daily irrigation of the cavity with eusol solution was begun in order to stimulate granulations and destroy the amoebæ. Eusol is a watery chlorine preparation, the active principle of which is hypochlorous acid, which was first used for amoebic abscess by Love in 1918 among the British troops in Mesopotamia.

Under this treatment, combined with emetine, repeated scrapings from the walls of the abscess were negative for amoebæ, and the cavity rapidly contracted in size. The general condition of the patient slowly improved for about two weeks, but he then gradually succumbed to exhaustion and uræmia and died twenty-two days after operation. No post-mortem examination could be obtained. At no time had the fæces shown amoebæ. The abscess which this patient had was the result of a latent amoebiasis of apparently many years' duration.

PERFORATED GASTRIC AND DUODENAL ULCER WITHOUT PREVIOUS PAIN

DR. GEORGE P. MULLER read a paper with the above title, for which see page 223.

CORRESPONDENCE

DISLOCATIONS OF THE SEMILUNAR CARPAL BONE

EDITOR OF ANNALS OF SURGERY:

SIR: In my article on Dislocations of the Semilunar Carpal Bone, published in the ANNALS OF SURGERY, May, 1921, pages 621-28, I note that an error is found on page 628. The sentence should read "Removal of the semilunar causes *no* interference with good function at the wrist." The sentence as it appears in the Journal reads as follows "Removal of the semilunar causes *an* interference with good function at the wrist."

You will readily see that the published statement is contrary to the impression that I was anxious to convey.

Respectfully yours,

ISIDORE COHN.

BOOK REVIEWS

INJURIES AND DISEASES OF THE BONES AND JOINTS. Their Differential Diagnosis by Means of the Röntgen Rays. By **FREDERIC H. BAETJER, M.D.,** and **CHARLES A. WATERS, M.D.** New York, 8vo. 394 pages. Paul B. Hoeber, 1921.

This book, from the standpoint of the röntgenogram, concerns itself with the differential diagnosis of injuries and diseases of the bones and joints. The literature on this vast and important phase of medicine and surgery—literature that is easily understood, readily comprehended, and pleasant to read—is, indeed, scarce. True, there are numerous books on röntgenology, the majority of which, however, are so highly technical, or whose contents are devoted so largely to the actual technic of röntgenology, or in which the clinical aspect of the case, as the doctor sees it in his office, is neglected, that they are of but little value to the clinician. Such, indeed, is not the case with the book under review. In its preparation, it is very evident that the authors were in close and constant touch with the operating surgeons at the Johns Hopkins Hospital.

In the text, one reads the main clinical points in the diagnosis. In the accompanying plates, of which there are 332, one sees illustrated, the differential points under discussion. The entire subject is presented thoroughly, systematically, and completely. To be brief, the authors consider normal bones, epiphyses, fractures, dislocations, bone infections, joint lesions, bone tumors, abnormalities, dystrophies, and present a separate chapter on the spine.

The reviewer predicts, for this book, a wide range and a useful future.

MERRILL N. FOOTE.

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